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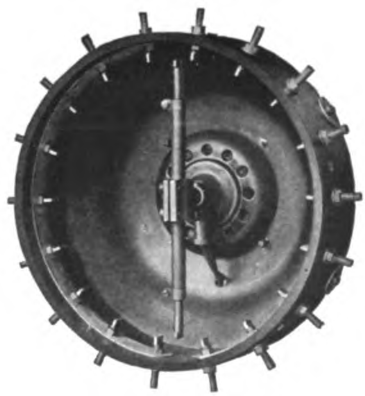

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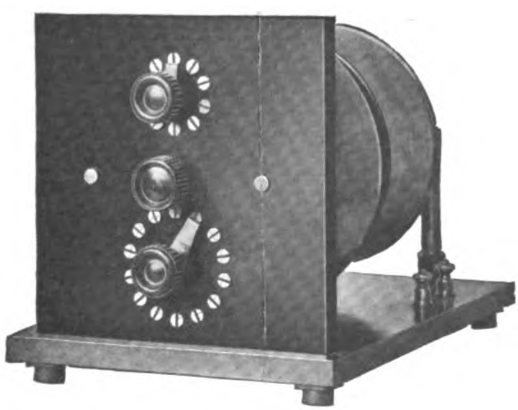

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THE WIRELESS AGE

An Illustrated Monthly Magazine of
RADIO COMMUNICATION

Published by WIRELESS PRESS, INC., 42 Broad St., N. Y. City.
Edward J. Nally, Pres. Charles J. Ross, Vice-Pres. David Sarnoff, Secy. John Bottomley, Treas.
J. ANDREW WHITE, Editor. WHEELER N. SOPER, Asst. Editor.
Volume 5 (New Series) October, 1917 No. 1

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ISSUED MONTHLY BY WIRELESS PRESS, INC.
42 BROAD ST., NEW YORK.
Yearly Subscription in U. S. $2.00; Outside U. S. $2.48; Single Copies, 20 cents
Entered as second class matter at the Post Office, New York.

THE FUTILITY OF IDLE COMPLAINTS

THE wireless man with the grievance is with us. He appears before the National Amateur Wireless Association by proxy regularly. Represented by a letter usually, his plea is that the closing down of his station, which at first seemed an injustice, has assumed the proportions of a tragedy. And then he airs his complaint and calls for drastic remedy, forgetting that we—all of us—

Stand by the Government.

The law must be obeyed. The nation is at war, and its interests ours. Everything that the President asks for must be given cheerfully. And it must not be forgotten that the experimental field in this country has been extended more privileges in peace times than is given by any other nation. A renewal of these privileges at the conclusion of the war is of paramount interest. To hold the recognition, amateurs must demonstrate unwavering, unquestioning loyalty in this hour of emergency.

This is no time for complaints.

Instead of wasting energy by bemoaning his fate, the experimenter should realize that he should be engaged in intensive study. Development of the art under war conditions is proceeding so rapidly that the well-informed man of today knows little tomorrow, unless he readjusts his point of view to embrace the new applications.

To those who cannot conceive existence without radio, the course is clear.

Enlist.

The Navy needs you.

The Army Signal Corps wants you.

Where physical and age limitations put up the bars to active service, there is always the field of the instructor to consider. But instruction is preceded by study.

WIRELESS SIGNALING FROM MILITARY AIRPLANES

THE extensive application of wireless to aircraft with which Mr. Marconi dealt so interestingly in the September issue of THE WIRELESS AGE opens up a wonderful field of new possibilities. The combination of flying with radio phenomena is unquestionably the most fascinating one which Fate could have devised for the American mind. Since the publication of the Marconi message to American amateurs, one of the most prominent military aeronautical engineers in the country has stated his belief that "the day is just around the corner when all aviators must be wireless operators, as well."

Thus an amplification of the present method of spotting artillery fire from airplanes should be of interest.

The observer in aircraft at the fighting fronts must have, aside from

his knowledge of wireless, some grasp of the fundamentals of artillery fire. He must know, for example, the trajectory of shells, or the arc they describe, and be able to distinguish between the use of field guns for barrage fire and howitzers for destruction of heavy guns. This knowledge is required because in locating his piece's objective he may have to fly low, and, after reporting the enemy location, ascend to a safe height above the trajectory of the shell fire which he thereafter directs.

The usual height of an observer's flight is 4,000 to 6,000 feet; flying in circles and figure 8s, he sends by wireless a report of the effect of each shot and directions for greater accuracy. A word or two, such as "right," "left," "too short," and so on, is the extent of the direction given, and so skilled are gunners and observers nowadays that it seldom takes more than three or four shots to score a hit on the enemy battery emplacement.

At night the positions are revealed by the lights required by the gunners and by the flash of the gun. While special knowledge is required for night flying, fire spotting in the inky darkness is really safer for the aviator, because of the consequent ineffectiveness of enemy anti-craft guns.

The wonderful accuracy with which a target is located is mainly due to the carefully prepared maps given to observers. These maps are divided into squares representing 1,000 yards a side and numbered. Subdivisions of these squares into four parts are assumed, and given the letters a, b, c, d. Thus the first report of a location might be "4c," the principle being then extended by further subdivisions of the sides of squares into 100 parts, the calculations being based upon the southwest corner as the point of origin, the first figure giving the distance east along the southern side and the second figure the distance north along the western side. Thus a corrected signal, "2732," would locate the enemy battery twenty-seven parts east and thirty-two parts north of the southwest corner of the map's square previously signaled. When it is realized that such an observation, accurately made, gives the location within ten feet, the airplane wireless man's great importance in war is realized more fully.

The maps are similar in appearance to those which appeared in the September article on map reading, in this magazine under "Signal Officers' Training Course."

The method of communicating with the airplane observer is one of great interest. While it is reported that great strides in improvement of receiving sets have been made, the problem of overcoming the noise of the machine and similar difficulties has meanwhile led to the adoption of visual means of transmitting directions to airmen. This is accomplished by white strips of cloth, 6 feet long by 1 foot wide, laid on the ground to form letters and symbols. These are easily visible from a height of 3,000 feet.

Assuming that the observer is serving three batteries and has been given the general direction and the nature of the enemy emplacement before rising, he will watch for specific directions as he ascends to the required height in safety behind his own batteries. The strips are then seen formed in the shape of the letter Z, which may mean "observe for time shrapnel," or perhaps a P, meaning, "observe for high percussion," or LYD, for high explosives. Later, at his post of observation he may note any one of these symbols prefixed by an X, meaning "change to," or maybe two strips in parallel, which tells him, "am not receiving your signals."

Both methods and codes change continuously, but the basic principles are as just outlined, from which it can be seen that the mastery of manipulation of the wireless and the air machine itself are the principal difficulties in preparing a military aviator for service.

In this new field lie wonderful opportunities for wireless men. They have scarcely been realized, but this much is definitely known. The skilled wireless operator receives preference in military aviation service.

GERMANY'S ABUSE OF THE S O S CALL

IN line with the stories told from time to time of the disregard of Germany for the rules of civilized warfare is the charge made by the survivors of the Norwegian ship Benguela. A German undersea boat captured the Benguela, and for sixteen days used her as a decoy by sending out S O S signals. The vessels which came in response to the call were promptly sunk by the U-boat.

The difference between the misuse of the S O S code and the treacherous sniping by Germans after they have indicated their wish to surrender, is that in the latter case there is usually swift punishment for the violators of the code. It follows also that when the German soldiers are guilty of such treachery their comrades, who have not offended, may have to suffer because their appeals for mercy are ignored.

On the other hand, generous tributes have been paid to the qualities of the Turk as a fighter. The conduct of the Turkish army on the battle line, no matter what excesses it committed in Armenia, has been up to the standard of the accepted code. The Turks are clean fighters, according to word from the front. They respect the insignia of the Red Cross, they treat their prisoners well and they do not seek to gain their ends by poisoning water.

It does not seem likely that Turkey would be guilty of using the S O S call as did the commander of the submarine which captured the Benguela. By contrast with Germany Turkey seems a model civilized nation.

WIRELESS STATIONS AND SPIES

DISCLOSURES by the United States showing collusion between Swedish and German diplomatic officers in transmitting military news from neutral countries to Berlin have again revived the subject of secret radio stations and their use by spies, although there is no proof that wireless was used in the cases in point.

In Buenos Ayres, which was the center of some of the German-Swedish activities, a secret wireless outfit was discovered several weeks before the disclosures were made. This equipment was located in a house at a considerable distance from the heart of the city in a street known, curiously enough, as Calle Estados Unidos (United States Street). The suspicions of the police regarding the house were aroused during the visit to Buenos Ayres of the United States squadron under Admiral Caperton. At that time the police said that they were satisfied that the wireless outfit was used to convey information concerning the ships. This information could not have been sent out by any other means, it was asserted.

Following the investigation in Argentina, a similar inquiry was begun in Uruguay, with the result that a wireless station was also discovered secreted in that country. The equipment was demolished by the police.

Revelations showing that a Swedish diplomat in Mexico had acted as the medium for transmitting military news to Germany give significance to a published story to the effect that what is believed to have been a German information forwarding wireless station was discovered on Lobos Island, a lighthouse station off the Mexican coast, northeast of Tuxpam. A Mexican Government official found a complete wireless set on this island. The equipment had been built by the lighthouse keeper, who was formerly a mechanic. He was unable to give a satisfactory account of how he had obtained the wireless apparatus, and he was placed under arrest.

Another station was also found in Campeche, at the mouth of the Champoaton River. As a result of these discoveries the Mexican coast is being scoured in search of wireless plants.

Such revelations bring to mind with considerable force the fact that the dangers of war are ever imminent, and that the spy menace is chief among them. No precautionary measures are being spared to guard the coastal stations of our country. Flood lighting is being employed to a considerable extent in radio-aerial and yard protection, and drastic means have been devised to keep away the unwelcome visitor.

As an instance of the vigilance which the guards exercise, it is related that a visitor who could not present a satisfactory excuse for his presence was recently ordered off the premises of a naval station by a marine. The visitor afterward preferred a technical charge of assault against the marine, but the United States Supreme Court has since sustained the latter for carrying out orders.

A MYSTERIOUS APPEAL AND WARNING

When the war is at an end it is likely that a lengthy chapter can advantageously be devoted to the unsolved mysteries of the struggle. To illustrate: A British steamship which arrived at an American port on September 15th brought reports that a German submarine was shelling a steamship sixty-five miles southeast of Nantucket on the previous day. Wireless messages to this effect had been picked up from the attacked craft, the story ran. The commander of the steamship did not turn back to go to the aid of the vessel because it was against the instructions of the Admiralty to do so. From the same steamship, apparently, came an S O S call a half an hour later. The commander of an oil tank steamship also reported having picked up the S O S, but the identity of the vessel in need of aid was not revealed.

The incident was shrouded still deeper in mystery by the information brought to port on September 16th by another American steamship, which reported that she had received the following warning from the Cape Ray wireless station at three o'clock in the afternoon of September 14th:

"Submarine seen near Nantucket Lightship early today. She is described as being 300 feet long, carrying one gun forward and one aft, and having two periscopes."

The operator at Cape Ray, published reports of the incident said, had attempted to get the name of the vessel sending the warning, but was unable to obtain a reply. The signals were very faint, he declared.

As a precautionary measure, the captain of the liner altered his course, but officers of the ship seemed doubtful regarding the genuineness of the appeal and the warning. Their doubts are shared by others who believe that the messages originated from a German source or were sent by irresponsible persons as a hoax.

AMATEURS FOR ESPIONAGE

ENDORSEMENT of the suggestion made in THE WIRELESS AGE that the amateurs of this country should be used for radio espionage has been given by others. It is their belief that one central large wireless sending station, installed somewhere in North or South or Central America, receives its information from spy operators.

This, of course, is mere surmise, but it has been proposed that amateur operators could be utilized to put an end to the putative wireless spy system. "Instead of forbidding these amateurs to receive messages," runs one comment on the subject, "they should be organized and encouraged to receive as much as possible, to keep a record of all they receive, no matter how inno-

cent the messages may seem, and to transmit this record every day to Washington."

Putting aside the consideration of the acceptance of this plan, the question of what is going on silently in the air during this war of the world provides opportunity for a wealth of conjecture.

TRAINING OPERATORS FOR THE NAVY

INTERESTING proof of the added recognition which the war has brought to wireless is found in the fact that the United States Navy is training radio operators at two schools, Mare Island, Cal., and Harvard University. Approximately 1,500 pupils, men of the regular service and the reserve, are undergoing instruction at Harvard, the buildings and facilities of the institution having been put at the disposal of the Navy by President Lowell. With the transfer of the regular Navy radio school, formerly at the New York Navy Yard, to Harvard, the wireless training activities of the service are now largely centered in Cambridge. The course is of four months' duration and embraces military drill as well as technical and other subjects. The men take their meals in Memorial Hall, the refectory erected in honor of Harvard men who fell in the Civil War, and use the Harvard gymnasium as a dormitory.

Seamen and apprentice seamen are given instruction in the rudiments of radio telegraphy at the naval training stations at Newport, R. I., Great Lakes, Ill., San Francisco, and Norfolk, Va., and at the naval camps at Philadelphia, Charleston, Mare Island, San Diego and Puget Sound. Those who are able to receive ten words a minute in the continental code and who show promise are transferred to Harvard for the four months' course.

The Regular Navy accepts enlistments under two ratings—landsman for electrician (radio) and electrician, third class (radio). For the former rating the recruit must be able to receive twenty-five words a minute in the Morse code or ten words a minute in the continental and possess a foundation in radio. For the electrician rating possession of a commercial radio license and ability to pass an examination in electrical subjects are necessary. Upon acceptance the recruits are sent to the radio school for instruction.

Five ratings are available in the Naval Reserve: Landsmen for electrician (radio); electricians, third class (radio); electricians, second class (radio); electricians, first class (radio); and chief electricians (radio). Men are enrolled in the first two classes according to their ability in the Morse or the continental codes, in the other ratings according to their experience as commercial radio operators on merchant vessels, and other qualifications.

Enlistments in the Navy or enrollments in the Navy Reserve for radio operators will be accepted at any Navy recruiting station. The monthly rate of pay for radio men ranges, on the present war basis, from $32.60 for landsmen to $72 for chief electricians.

MR. SWANSON'S WORK IN THE TROPICS

Additional details regarding the scientific expedition of Dr. Alexander Hamilton Rice and the members of his party into the wilds of Rio Negro, South America, an account of which was published in the September issue of The Wireless Age, show that the success of obtaining the time signals from Washington along the Amazon and Negro Rivers was due to the efforts of John W. Swanson, United States Government radio inspector, of New York City, who accompanied the explorers as wireless expert. He employed a small, portable wireless set, which was assembled by Paul Godley of Upper Montclair, N. J. Mr. Godley is not unfamiliar with wireless in the tropics, having had experience at the station at Manaos, Brazil.

Mr. Swanson's work, it is said, was the first ever attempted in utilizing the Arlington signals under the conditions that existed. It will have a place in wireless history.

Radio Science

MEASUREMENT OF THE INTENSITY OF WIRELESS TELEGRAPH SIGNALS WITH THE OSCILLATING VACUUM VALVE*

MEASUREMENT of the strength of the incoming signals at a wireless telegraph station or of the relative power required to give an audible sound in the receiving telephone, has engaged the attention of radio telegraph engineers for a number of years. Although galvanometers which are exceedingly sensitive and can be employed for direct measurement, have been developed, they have proved almost wholly impracticable on account of the intensity of atmospheric disturbances.

The usual procedure, therefore, has been to shunt the telephone by an adjustable resistance having a scale calibrated directly in terms of audibility.

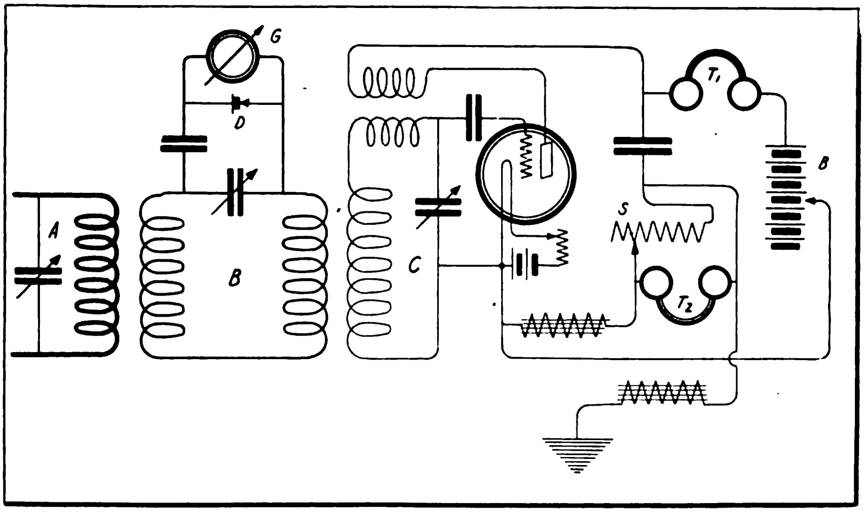


Figure 1

This resistance is gradually reduced in value until the signals from a given transmitting station are barely audible. If t is the effective resistance of a telephone for a particular frequency and wave form of the current, and s the value of the shunt, then the audibility factor,

$$A=\frac{t+s}{s}$$

When made by a properly trained or experienced ear, such observations of audibility will suffer an error no greater than ten per cent., but under the conditions found in the ordinary wireless station the error is seldom less than twenty per cent. and sometimes may reach a value of fifty per cent.

There has been considerable criticism of this method of measurement broadcast during the past few years owing to the elusive quantities involved as well as the personal equation in observations. But in a recent issue of the Proceedings of the Institute of Radio Engineers, Dr. L. W. Austin of the United States

*Abstract from the Proceedings of the Institute of Radio Engineers.

Naval Radio Telegraphic Laboratory endeavors to show that the shunted phone method is quite within the limits of experimental error, even when applied to the oscillating vacuum valve detector circuit of the type in use in the United States Navy.

Briefly told, this measurement was carried out by setting up an artificial antenna circuit (Figure 1) fitted with a silicon detector, D, shunted by the galvanometer, G, the circuit, B, being inductively coupled to the source of radio frequency oscillations, A. The oscillating vacuum valve circuits are indicated at C, the circuit being coupled to the artificial antenna, B. The observations were made with the view of determining the ratio of the current ratio to the audibility ratio with various ranges of audibility at the receiver.

First the current in circuit B was varied by changing the coupling with A, and the range of audibility in the vacuum valve circuit C was fixed by the coupling, B. The observations were carried out by means of a telephone having a direct current resistance of 2,040 Ohms and a current sensitiveness of 5×10^{-10} at a frequency of 1,000 sparks per second. The procedure follows:

With a variation of the coupling, A, B, the coupling between B, C was fixed, corresponding audibility and galvanometer readings being noted. The coupling, B C, was then changed and the observations repeated for a new audibility range. The result of five sets of observations follows:

TABLE 1

Ranges of Audibility	$\frac{\text{Ratio of Current}}{\text{Ratio of Audibility}}$	Sets of Observations
1- 2	0.95	6
1- 10	0.93	6
10- 100	0.94	5
100-2,000	1.05	7
250-5,000	1.03	16

A second set of observations were taken with audibilities from three to eighty, showing further that the $\frac{\text{current ratio}}{\text{audibility ratio}}$ varies from 0.03 to 1.15, a fairly close agreement. These data are shown in Table 2.

TABLE 2

Audibility Ratio	Current Ratio	$\frac{\text{Current Ratio}}{\text{Audibility Ratio}}$
$\frac{12}{3}$	$\frac{5.24}{1.14}$	1.15
$\frac{20}{3}$	$\frac{7.78}{1.14}$	1.02
$\frac{50}{3}$	$\frac{19.24}{1.14}$	1.01
$\frac{80}{3}$	$\frac{28.8}{1.14}$	0.95
$\frac{20}{12}$	$\frac{7.78}{5.24}$	0.89
$\frac{50}{12}$	$\frac{19.24}{5.24}$	0.89
$\frac{80}{12}$	$\frac{28.8}{5.24}$	0.85
$\frac{50}{20}$	$\frac{19.24}{7.78}$	0.99
$\frac{80}{20}$	$\frac{28.8}{7.78}$	0.93
$\frac{80}{50}$	$\frac{28.8}{19.24}$	0.93

The absolute sensitiveness of the navy three-electrode regenerative vacuum valve circuit next came up for discussion, and it was mentioned that the relative audibility of the oscillating vacuum valve to the plain vacuum valve circuit was about 600. Also, the mean sensitiveness of the old type of vacuum valve circuit

was found to be 1.7 times that of the three-wire electrolytic. It is further mentioned that in the earlier Brant Rock tests, it was determined that it required 25×10^{-10} to produce an audible signal in the receiver telephone, but with the improved modern telephone this figure has been reduced to 12.25×10^{-10} watts.

It is estimated that the least power capable of producing a signal in the oscillating vacuum valve is 1.2×10^{-15} watts, which is more than 10^{-16} times the watt sensitive of the electrolytic.

From this value a table was calculated, assuming that the oscillating vacuum valve produces a current variation in the telephone proportional to the square root of the received watts.

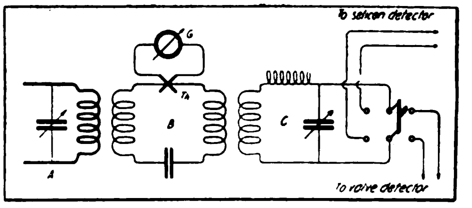


Figure 2

A series of measurements were carried out by Dr. Austin, to determine with greater certainty the sensitiveness of the vacuum valve, and to secure a direct determination of the power in the receiving system corresponding to unit audibility in the vacuum valve. The arrangements of the apparatus are shown in Figure 2. The wavemeter, A, was excited by an oscillating valve which permitted loose coupling between the circuits, A B. A sensitive vacuum thermoelement of twenty-eight ohms resistance was placed directly in the circuit of A and connected to a galvanometer, D. A double-pole double-throw switch was included in the C circuit so that the receiving circuit proper could be connected to the vacuum valve or to a silicon-detector galvanometer. When the silicon detector was adjusted to give the largest deflection on the silicon galvanometer, a comparison was made between the thermoelement deflection in circuit B and the detector deflection in C. By exterpolation the galvanometer, G, was employed to measure the radio frequency current in C.

The result of some observations on a circuit adjusted to the wave-length of 3,000 meters follows:

The resistance of the B circuit plus that occasioned by the coupling of the C circuit, was found to be sixty-five ohms. The inductance of the secondary of the C circuit was twelve microhenries. One millimeter deflection of the silicon detector galvanometer corresponds to 6.2 (10)-6 amperes in circuit B. In table No. 3, which follows, I is the current in circuit B, W is the watts in circuit B, A is the corresponding audibility on the vacuum valve, and Wo is the ratio of $\frac{W}{A^2}$ in other words, the watts for unit audibility.

TABLE 3

$\lambda = 3.000$ m.
R=65 ohms.
Lc=12 m h.

D	D	I	W	A	W
		10^{-6} amps.	10^{-10} watts		10^{-15} watts
2.3	1.52	9.4	57.2	2,500	0.92
4.0	2.00	12.4	100.1	3,000	1.11
2.0	1.41	8.7	50.1	2,000	1.25
2.2	1.48	9.2	55.2	2,300	1.02
4.0	2.00	12.4	100.1	3,000	1.11
					1.09 Average

Other observations were made on wave-lengths of 3,000, 6,000 and 10,000 meters, using secondary inductances of twelve microhenries and thirty-six microhenries. It is found that the average power required for unit audibility over this range of wave-length amounted to $1.45\ (10)^{-15}$.

In the discussion which followed it was brought out by Edward H. Armstrong that the average radio experimenter's concept of audibility is a misnomer. He said:

"Primarily, when we speak of the audibility of a signal in a telephone, we have a concept of the energy necessary to produce that signal. We would naturally suppose that when a telephone is supplied with four times the energy necessary to give unit audibility that the audibility of that signal would be four. Certainly the amount of energy which has gone into the production of sound

waves is four times that necessary for unit audibility. But by the present standard, since the telephone current is only twice the value of the current necessary for unit audibility, the audibility is only two. This leads to an absurdity in the case of the oscillating audion receiver. One of the great virtues of this receiver, and in fact of nearly all heterodyne receiving systems, is that the energy delivered to the telephones is directly proportional to the received energy. But according to the present definition of audibility, it becomes necessary to say that the audibility is proportional to the square root of the received watts!"

In a further discussion of this paper, Armstrong attempts to prove by a simple analogy that the power received in the antenna circuit fom the signalling source is distinctly more different when employed with the regenerative receiver than when used with a simple crystal rectifier. This is due to peculiar phenomena of the regenerative circuit. In fact, the effect of the local or regenerative E. M. F. is to increase the power supplied to the antenna system by the signalling source by an amount approximately equal to $\frac{E_2}{E_1}$

Where E_2 equals the final value of the steady regenerative E. M. F. and E_1 equals the signalling E. M. F. the limitations of the analogy are discussed. It is also shown that the Austin formula for the current received at a given station requires a considerable modification for use with regenerative circuits, being made to read as follows:

$$I_r = \frac{(1+E_2)}{E_1} \; \frac{377 h_1 \, h_2 \, I_s}{\lambda \, d \, R} \, \epsilon^{\frac{-0.0015d}{\lambda}}$$

Furthermore, on account of the presence of the regenerative electromotive force, E_2, a proper understanding of the term "received current" is in order. It is remarked that the electromotive force due to the incoming waves and that part of the power in the antenna which is actually drawn from the energy of the waves, are the only quantities which can properly be termed "received current."

AN UNDER-SEA TELEGRAPH EQUIPMENT

FOLLOWING up, to a greater or lesser extent, Professor Morse's earth current telegraph system, which he devised and employed in the year 1842, Frank P. Fischer and Hugh Dehart, of Radford, Va., have devised a scheme of undersea communication which they believe can be profitably utilized by submarines for short distance communication.

As will be seen in Figure 3, the transmitter employs an induction coil with a telegraph key and battery, the secondary terminals of the coil being connected to two metallic plates, P-1 and P-2, which are separated by a certain distance and submerged in the ocean. When the telegraph key is closed, an alternating current is induced in the secondary winding of the induction coil, S, which flows to and fro between plates P-1 and P-2.

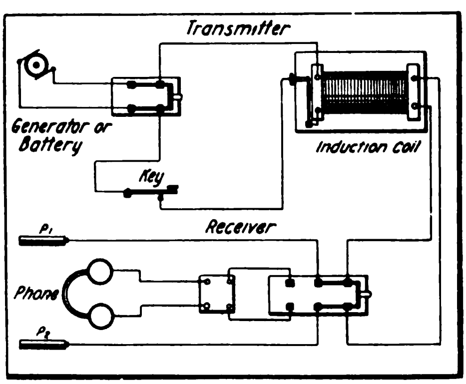


Figure 3

A similar set of plates is provided at the receiving station, being immersed in the water, and, as will be observed in the diagram, they are joined together by a copper conductor in series with which is placed a telephone receiver. A part of the current flowing from plate to plate at the transmitter subdivides,

takes the path afforded by the copper conductor from plate to plate at the receiver, and accordingly, sounds are produced in the head telephones which can be the ordinary Morse characters.

It is, of course, apparent that this system does not employ electric waves in any manner, it simply being an extension of the often used earth current system. The system is expected to have some application for communication from submarines when submerged, and it is also believed that it may be of use in locating sunken submarines. But the way in which this is to be accomplished has not been explained.

ADAPTING THE VACUUM VALVE FOR USE WITH THE EINTHOVEN GALVANOMETER AND PHOTOGRAPHIC DEVICE

THE Einthoven galvanometer has frequently been employed in connection with a photographic recording device for the reception of radiotelegraphic signals, particularly in connection with crystal and magnetic detectors. But it has not been found possible to use it with the vacuum valve on account of the large volume of current flowing in the local telephone circuit. This often

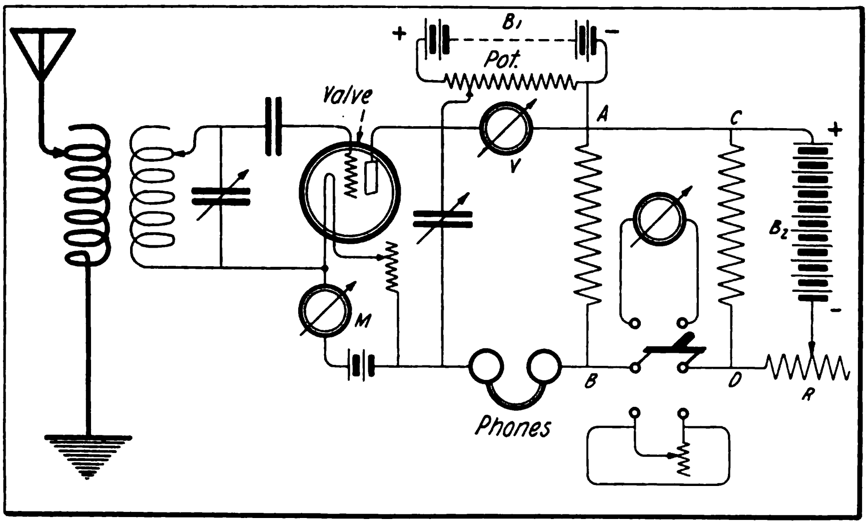


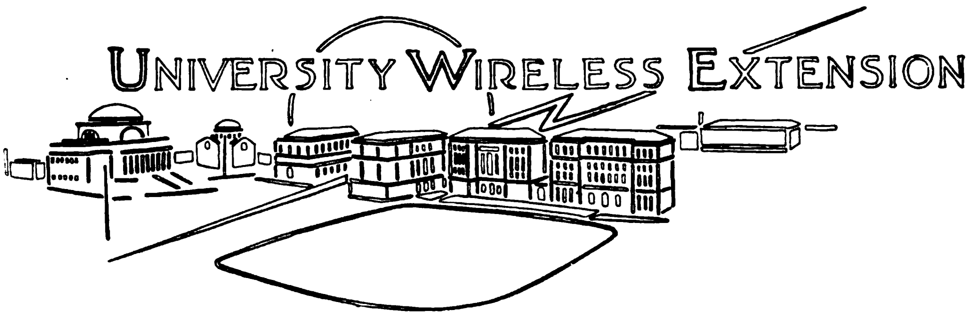
Figure 4

amounted to one or two milliamperes, which of course would not permit a sensitive instrument such as the Einthoven galvanometer to be inserted directly in the measuring circuit.

In a recent issue of the Physical Review, a method is shown whereby the vacuum valve can be employed with this galvanometer and photographic recorder, in a relatively simple manner. Referring to Figure 4, a resistance coil, A B, is inserted in series with the telephone and the battery, B-1, of the local telephone circuit, and accordingly a potential difference exists across its terminals. But this is balanced by an equal potential difference across the resistance coil, C D, which is fed by the battery, B-2. An additional small regulating resistance, R, is connected in series with C D to obtain a perfect balance.

When signals are not being received, the galvanometer, if the circuits are in proper adjustment, will give no deflection, but when signals *are* received, the potential difference across A B varies, which disturbs the balance and causes a deflection of the galvanometer in accordance.

The writer mentions that it was found most satisfactory to keep the resistance of the coils, A B and C D, at about 2,000 ohms.



Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE X

7. **MODULATION CONTROL IN RADIO TELEPHONY.** We have, up to this point, considered many matters which are common to radio telephony and radio telegraphy since the sustained wave generating systems are naturally applicable to the latter field as well as the former and indeed were originated principally in connection with telegraphy. We pass, now, however, to a matter exclusively related to radio telephony, namely the modulation or control of amounts of power varying from a few watts to many kilowatts *by the human voice.* The problem is indeed a difficult one, and for a long time practically defied solution. When it is considered that the rate of energy radiation in the form of sound in ordinary speech is of the order of one one-hundred-millionth to one billionth (0.000 000 01 to 0.000 000 001) of a watt, and that the delicate and excessively complex variations of the sound energy must be faithfully reproduced with an energy amplification of *hundreds of billions,* and that the energy to be modulated is of the peculiar form associated with radio frequency currents, the difficulties of the problem become evident. And yet radio telephony is entirely dependent on the simple solution thereof.

Before describing in detail the various methods of modulation control which have been devised, we shall consider certain broader questions connected therewith. The first of these is the completeness of control systems.

(a) **DEGREE OF CONTROL.** In every radiophone transmitter, there is some point at which a controlling current, voltage, inductance, capacity, or resistance exists. The current might be, for example, the fluctuating current in a telephone transmitter circuit. The voltage might be the voltage applied to the grid of a vacuum tube of some sort, this voltage being derived from the secondary circuit of a transformer connected in a microphone transmitter circuit. The resistance might be the resistance of a microphone placed directly in the antenna of a radiophone transmitter. Whatever the controlling element, it must vary between certain extreme values when speech is being transmitted, these limits being reached for the peaks of the loudest sounds which are en-

countered in ordinary speech. Indeed, it is preferable that these peaks should be reached for such normal speech rather than for shouting since otherwise the control tends to be weak and excessive amplifications may be required somewhere in the set.

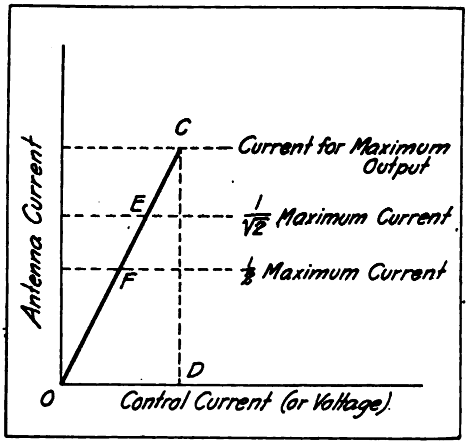


Figure 115—*Complete linear modulation control curve*

In Figure 115 we have a control characteristic of a desirable sort. Horizontally is plotted the controlling element (current, voltage, capacity, inductance, resistance, or a combination of these), this element varying between zero and the value *OD*. Vertically are plotted values of the controlled or antenna radio frequency current, this varying between zero and *CD*. It will be seen that we have a straight line characteristic curve; that is, the controlled current is proportional to the controlling current. Furthermore, the control is complete, since we assume that the current *CD*, is the greatest current which the sustained generator is capable of putting into the antenna; or, in other words, the current *CD* is determined by the actual maximum possible output of the alternator, arc, radio frequent spark transmitter, or vacuum tube transmitter used.

The question arises as to what will be the ammeter reading in the antenna when no speech is being sent out. This depends on whether we choose to have this point as that of half current or of half energy. In the former case, the current will center around the point *F* which represents one-half the maximum current. In the latter case, the current will rise and fall about the point *E* which represents the reciprocal of the square root of two (that is, 0.707) times the maximum current. Under normal conditions of speech, in some types of radiophone (particularly those with stable control to be described hereafter) the antenna ammeter does not change markedly from the point *E* (or *F*) when one actually carries on conversation. In other types (and especially those with unstable control) the average current in the antenna may change considerably when speech is being transmitted.

A curve representing incomplete control is given in Figure 116. It will be noted that the entire available variation in the controlling element will cause a variation in the antenna current only between the values *OG* and *DA* and not between zero and the maximum available current *CD*. In this case we may define the percentage of control as the quotient of *AB* divided by *CD*. Such a radiophone set with a normal linearly proportional receiver will be equivalent to a considerably less powerful transmitter than that represented in Figure 115.

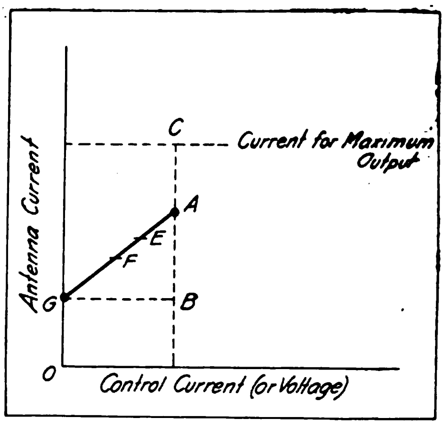


Figure 116—*Incomplete linear modulation control curve*

The Author advocates control characteristics in which the microphone current is taken as the controlling element and the antenna current as the controlled element. First of all, these elements are

fairly readily measurable. In the second place, what is, after all, desired is that the *current* variations through the receiver telephones shall be proportional to the *current* variations in the microphone transmitter as in an ordinary telephone line. It is accordingly deemed best to adhere to current control characteristics throughout.

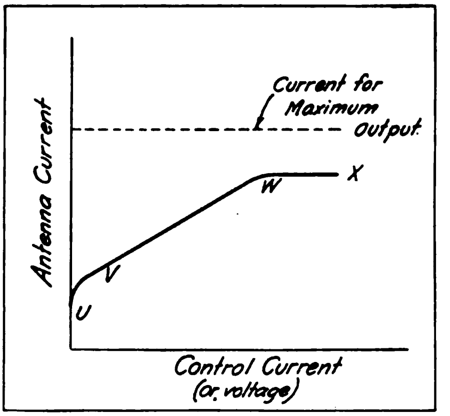


Figure 117—*Typical incomplete non-linear modulation control curve*

In practice, the perfect type of control characteristic shown in Figure 115 is not realized. A more common form which is fairly acceptable is shown in Figure 117. It will be seen that the antenna current never falls below *U* although this leads to a waste of energy. From *V* to *W* the control is linear and satisfactory, but at *W* it flattens, remaining at constant current to *X*. The maximum output current is never reached, the mere existence of the controlling element preventing its attainment.

(b) **STABILITY OF CONTROL.** The control system of a radiophone may be classified as stable or unstable depending on whether the points on the upper and lower portions of the control curve can be held steadily with the control system used or whether they can be reached for only a brief period of time. The simplest example of a stable control system would be the following: Imagine a radio frequency alternator, driven by a constant speed motor, placed directly in a tuned antenna; and in series with the alternator and directly in the antenna a microphone transmitter (or a variable resistance, which is its equivalent). It is evident that the system is perfectly stable no matter what the value of the microphone resistance, since the only possible effect of an increase or diminution of the microphone resistance is to lower or raise the antenna current. The control curve of such a system would be a "static" characteristic; i. e., one for stationary conditions. The simplest example of an unstable control system would be the following: A Poulsen arc is placed directly in the antenna in series with a microphone (or a variable resistance). Changing the resistance of the microphone will not merely cause the antenna current to change; it may actually cause the extinction of the arc altogether, if the inserted resistance is too high. So that the system would be unstable at this limit. This is illustrated in Figure 118 where the antenna circuit is plotted against time. The current remains constant from *P* to *Q*, it being supposed that the resistance in the antenna is moderate for this range of time. At *Q* a large resistance is inserted in the antenna, for example, by speaking into the microphone, or pulling out its diaphragm. The antenna current may not merely decrease; it may rapidly fall to zero at the point *U*. On the other hand, if the resistance is restored to its former small value after a time *RT*, the antenna current may recover the full value *Q* rapidly. In other words, while the system is unstable for permanent changes, it may be operative for rapid transient changes provided these changes are of very short

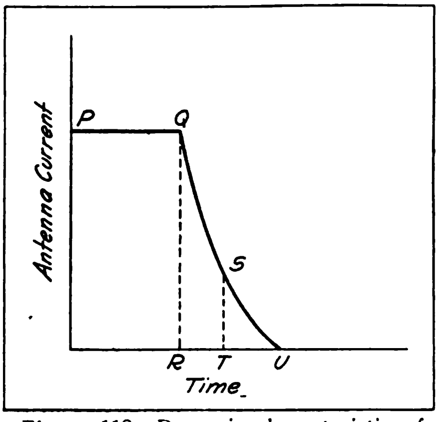


Figure 118—*Dynamic characteristic of falling current for unstable control system*

duration. For this case, it is not possible to secure a complete static control characteristic; dynamic characteristics must be obtained by the use of an oscillograph or some other device for following the rapidly changing antenna and controlling currents.

Generally speaking, unstable control systems are objectionable. If the time *RU* of extinction in such a system is very short, then a low-pitched sound (of relatively long period) may lead to complete "breaking" or extinction. On the other hand, if the time *RU* is long and the slope of *QSU* less abrupt, there will be sluggishness of control and a blurring or muffling of speech. Rigid and stable control is desirable.

(c) **RATING OF RADIOPHONE TRANSMITTERS.** In a receiving set, when audibility measurements are being made on received speech (on the basis of just hearing sound of any character), it is the maximum transmitter current (*CD* of Figure 115) which is being considered. Consequently the Author recommends that radiophone transmitters be rated on the basis of maximum energy radiated, corresponding to maximum current. Here 100 per cent. control is assumed. If less than full control is attained, the rating of the transmitter should be the *maximum energy variation.* As has been stated, for unstable control systems, this requires an oscillograph for the determination of rating; but generally we may assume the maximum energy in this case to be twice the average or steady value, if the control is known to be linear. Many unstable control systems flatten out in control (as at *WX* in Figure 117) for high currents, and consequently their rating may be much less than that given by the double energy rule above.

In rating radiophone transmitters on the basis of maximum energy radiation, it must be understood that this does not imply that a 1 K.W. radiophone transmitter will enable the clear transmission of speech for the same distance as a 1 (antenna) K.W. spark transmitter will enable the transmission of telegraphic signals. More than just the peaks of the received speech is required for comprehensibility, so that the received speech must be considerably more than once audibility to be fully understood. The exact number of times audibility is required for satisfactory speech is not precisely determined at present and depends naturally on the freedom from speech distortion. It is probably not less than 2 nor more than 10.

(d) **TYPES OF CONTROL.** Control systems may further be classified as absorption systems or generator voltage (or current) control systems. The simplest instance of an absorption system is the plain microphone-in-antenna modulation where the microphone actually absorbs intermittently a considerable portion of the radio frequency generator output. Such systems, while distinguished by their simplicity and satisfactory behaviour for small powers are not so easy to apply to large powers because of the difficulty of absorbing considerable acounts of energy in any system sufficiently delicate to follow the voice inflections. One exception to this statement, however, are the vacuum tube absorptive systems to be described hereafter.

The generator-voltage control type is well illustrated by the use of radio frequency alternator in the antenna, the field of the alternator being excited by the microphone current and the alternator being driven by a constant speed motor. It will be seen that the generator output is variable in this case, and not constant as in the former. This requires quite special driving motors and is an objection. On the other hand, the absorption control systems tend to be constant load systems and do not require special driving machinery. However, unless an absorption system is carefully devised, it may be uneconomical of energy, since it is desirable to avoid having full load on all machinery regardless of whether speech is being transmitted or not.

(e) **MICROPHONE TRANSMITTER CONTROL.** An ordinary microphone transmitter of high resistance will carry a steady current of from 0.1 to 0.2 ampere at an applied voltage of 10 volts. Its resistance is therefore of the order of 50 to 100 ohms, and the energy which it can absorb steadily is about 2 watts. If it is attempted to pass more current than that mentioned through the microphone, a "frying" or crackling sound will be heard in the receiver, the carbon grains of the transmitter will overheat and burn, and the microphone will steadily deteriorate. A so-called "low resistance" transmitter will carry 0.4 to 0.5 ampere and have a resistance of from 10 to 20 ohms. It can absorb satisfactorily but little more energy than the high resistance form.

When a microphone overheats from the passage of excessive current, which is very likely to occur when the over-enthusiastic radiophone experimenter places it in the antenna circuit and attempts gradually to increase the antenna current, it "packs". That is, the grains of carbon expand and become tightly wedged in the carbon chamber and the microphone no longer responds. It then becomes necessary to shake the microphone mechanically to release the grains and restore its modulating power. In one form of radiophone made by Dr. de Forest, the shaking of the microphone was accomplished by fastening a buzzer to it and closing the battery circuit of the buzzer occasionally. The resulting vibration gave the desired result. A more simple means of accomplishing the same result is by tapping the transmitter. A "packed" transmitter rapidly deteriorates through overheating and burning of the carbon grains.

Dr. George Seibt has shown that, in order that the loudest signal shall be heard in the receiving station when a microphone transmitter is used for modulating the transmitted energy, a simple condition must be fulfilled. It is that the resistance (as determined by energy absorption of the microphone when undisturbed) shall be equal to the total resistance (as determined by energy absorption) of the remainder of the radio frequency circuits of the transmitter. For example, imagine an antenna of 8 ohms total resistance (including ohmic resistance, ground resistance, radiation resistance, and eddy current loss resistance) with an inserted microphone. The microphone resistance should also be 8 ohms. From this it is fairly obvious that a high resistance microphone is inapplicable, unless it is not in the antenna but so coupled or connected to antenna circuit (directly, inductively, or capacitively) that its effect is the same as if a smaller resistance equal to the antenna system resistance had been inserted.

We show in Figure 119 a number of arrangements which have been used for the direct control of the radiated energy by a microphone. Diagram *a* shows the microphone inserted in the direct current supply leads of the arc, thus causing appropriate variations of the arc current and arc output. Diagram *b* is somewhat different in that alternating electromotive forces are impressed on the arc as well as the constant supply voltage. The alternating voltages are transferred to the arc supply circuit through the transformer *T* connected to the microphone circuit and supply circuit. This arrangement is due to Mr. E. Ruhmer. In the Diagram *c* the microphone has been transferred to the oscillating circuit of the arc. This method would, except with very low resistance microphones, be an unstable control system. In Diagram *d*, which shows a circuit used by both Professor V. Poulsen and the Telefunken Company, the microphone is shunted across the antenna coupling and tuning coil. It would therefore act to detune the antenna circuit as well as to absorb energy intermittently. The method is quite effective. Diagram *e*, which is another arrangement due to Professor Poulsen, accomplishes the same results by coupling the microphone inductively to the antenna coupling coil. The only purpose of the battery in this case is to bring the microphone resistance (which depends on the current passing through it) to a desired value. Diagram *f* illustrates an arrangement

used by Mr. Fessenden (principally with radio frequency alternators as generators) and others. In this simple case the microphone is directly in the antenna, and moulds the radio frequency current into the desired speech form envelope more or less fully. Diagram *g* shows the unusually elaborate arrangement adopted for modulation by Messrs. Colin and Jeance. A tuned circuit of desired constants is directly coupled to a portion of the antenna coupling coil. The microphone is directly inserted in the tuned shunting circuit which has sometimes been characterized as a "spill-over" circuit.

In order to modulate more energy than can be properly handled by one microphone, the idea was originated of using several in series, low resistance

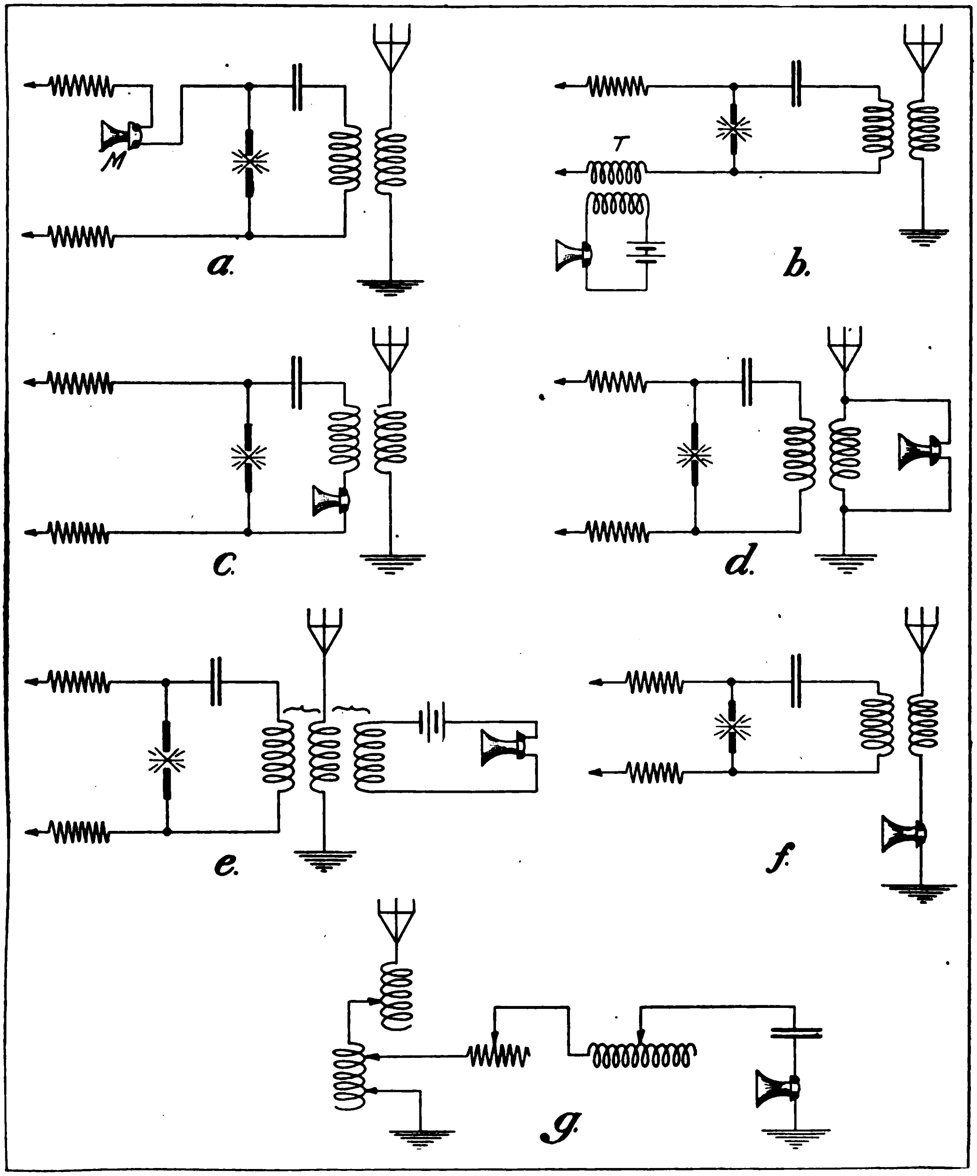


Figure 119—Various arrangements for microphone modulation of radiophone transmitter

microphones being thus employed. The idea is feasible to a limited extent, but rapidly leads to difficulties in carrying the energy of the speech to the diaphragms of many microphones. An extreme instance of this method is shown in Figure 120, which shows no less than 25 Berliner microphones being thus used by the C. Lorenz Company. A less extreme instance is illustrated in the radiophone set illustrated in Figure 23 in a preceding article, which shows 6 microphones in series. It is desirable in such arrangements to have the paths from the mouth of the speaker to the different microphones of equal length and as nearly as possible geometrically identical, so that each microphone gets full excitation.

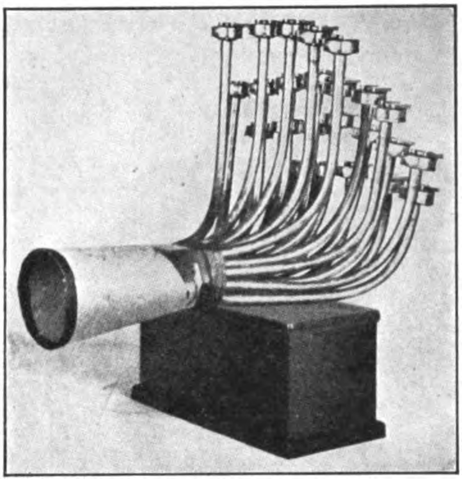


Figure 120—*C. Lorenz Company multiple transmitter*

A further expedient is to have more than one set of microphones available, and to change over from one set to the next whenever considerable heating occurs. Data is not available as to the practicability of this scheme, but it seems to be of some advantage.

Mr. R. Goldschmidt has devised a method of using several microphones in parallel. Normally this is not feasible, since if one begins to get more current than the remainder its resistance will rapidly fall and it will soon carry the entire current, thus leading to injurious overheating. The simplest form of the method mentioned is given in Figure 121. As will be seen, the microphones are each

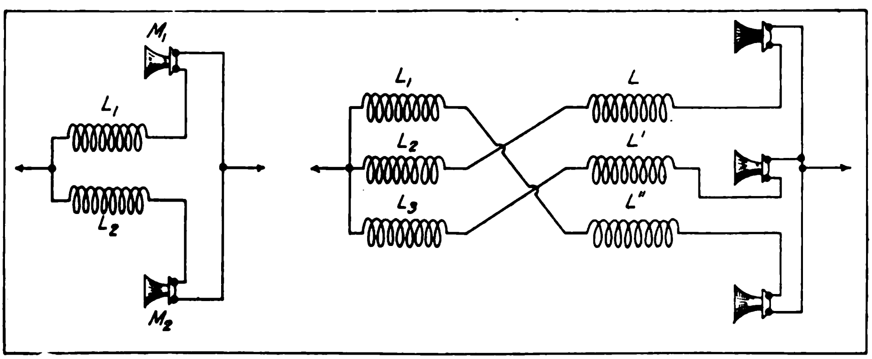


Figure 121—*R. Goldschmidt's method of utilizing microphones in parallel*

in series with a coil (L_1 and L_2 respectively). The coils in question are wound oppositely on a common core. As long as the current through each microphone is the same, equal currents will flow through each coil and the net inductance in the circuit will be zero. If, however, one of the microphones takes more current than the other, the balancing current begins to circulate in the circuit $L_1M_1M_2L_2$ and encounters a high inductance in L_1L_2 since it does *not* flow in the opposite direction in the two coils. The method of extending the idea to three microphones is also illustrated. Here coils L_1 and L are wound on the same core, as also are the coils L_2 and L', and the coils L_3 and L''.

(f) **HIGH CURRENT MICROPHONE CONTROL.** The first thought that naturally suggests itself in connection with the securing of microphones that will modulate successfully more energy than will the ordinary carbon microphone is to replace the carbon by some more permanent and less inflammable material. Carborundum has been suggested by several inventors, but it cannot be said that any data is available favoring the belief that the expedient was successful.

In 1906 and 1907 Mr. R. A. Fessenden, at that time directing the work of the National Electric Signaling Company, devised a number of microphone transmitters which carried heavy currents for considerable periods of time. He also developed a heavy current telephone relay, which permitted controlling considerable current by means of smaller currents originating in an ordinary microphone circuit or coming from a telephone line. A description of these devices in his own words, with added comments by the Author, follows:*

"A new type of transmitter was therefore designed which the writer (Mr. Fessenden) has called the "trough" transmitter. It consists of a soapstone annulus to which are clamped two plates with platinum iridium electrodes. Through a hole in the center of one plate passes a rod, attached at one end to a diaphragm and at the other to a platinum iridium spade. The two outside electrodes are water-jacketed.

"The transmitter requires no adjusting. All that is necessary is to place a teaspoonful of carbon granules in the central space. It is able to carry as much as 15 amperes continuously without the articulation falling off appreciably. It has the advantage that it never packs. The reason for this appears to be that when the carbon on one side heats and expands, the electrode is pushed over against the carbon on the other side, (thus diverting a greater portion of the total current to the cooler side, which has thus been made of smaller resistance. It will be noted that the two halves of the carbon, on the opposite sides of the spade diaphragm are in parallel). These transmitters have handled amounts of energy up to one-half horse power (375 watts), and under these circumstances give remarkably clear and perfect articulation and may be left in circuit for hours at a time."

Such a water-cooled microphone, built to carry up to 6 amperes continuously, and suitably mounted, is illustrated in Figure 122.

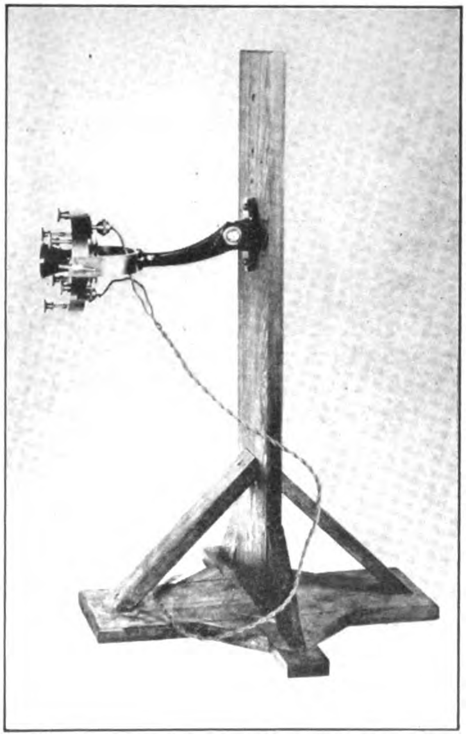


Figure 122—National Electric Signaling Company-Fessenden high current transmitter

A more complex and extremely interesting device is shown in Figure 123. This is† "a transmitting relay for magnifying very feeble currents. It is a combination of the differential magnetic relay and the trough transmitter. An amplification of 15 times can be obtained without loss of distinctness. The successful amplification depends on the use of strong forces and upon keeping the moment of inertia of the moving forces parts as small as possible. Amplifica-

* "Proc. A. I. E. E.," June 29, 1908.
† "Proc. A. I. E. E.," June 29, 1908.

tion may also be obtained by mechanical means, but as a rule this method introduces scratching noises which are very objectionable even though comparatively faint." The amplifying relay shown in Figure 123 is capable of handling 15 amperes in its output side. Thus some ten years ago Mr. Fessenden recognized the desirability of being able to control the radiophone transmitter from a wire line, and this relay was developed to enable the desired result to be obtained.

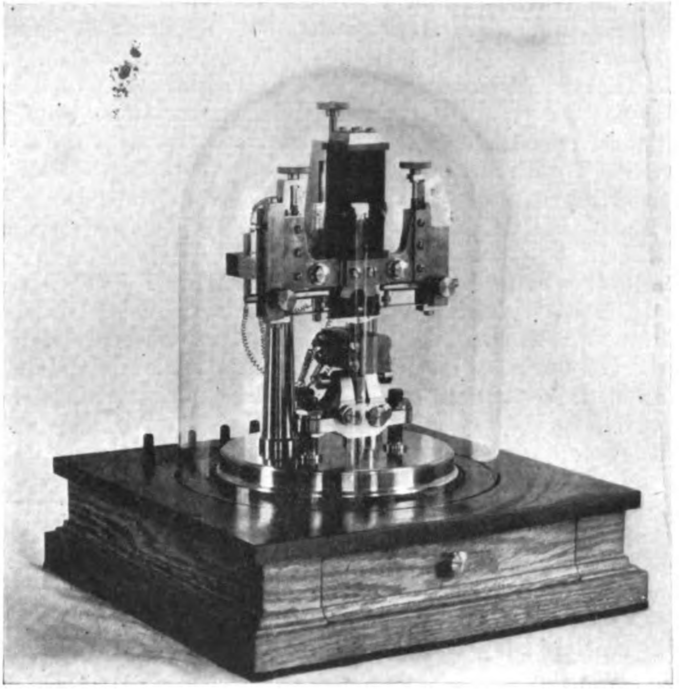


Figure 123—*Fessenden heavy current telephone relay*

A complete radiophone station at Brant Rock embodying the idea just mentioned is illustrated in Figure 124. Although completed in 1906, the design thereof was remarkably advanced. In the right foreground are seen the radio frequency alternator and its driving motor and controlling rheostats. Directly back of these is a compressed air tuning condenser. On the table is shown a normal line telephone set connected to the high current relay which controls the outgoing energy. In addition, at the reader's left, on the table is placed a portion of the receiving set. On December 11, 1906, a demonstration of radio telephony was given from Brant Rock to Plymouth, Massachusetts, a distance of 10 miles (16 km.). Both speech and music were transmitted. In addition, speech was transmitted over an ordinary wire line to the radio station at Brant Rock, relayed automatically to the radiophone, transmitted by radio to Plymouth, and at Plymouth automatically relayed back to a wire line. Telephone experts present noted a remarkable absence of distortion of speech quality. In July, 1907, speech was transmitted between Brant Rock and Jamaica, Long Island, a distance of 180 miles (290 km.) over land, and by day. The antenna mast at Jamaica was 180 feet (55 m.) high. In this work, "the transmitting relays are connected in the wire line circuit in the same way as the regular telephone relay, except that in place of being inserted in the middle of the line, they are placed in the radio station and an artificial line used for balancing. There is no difficulty met with on the radio side of the apparatus, but on the wire line there are the well-known difficulties due to unbalancing which have not been entirely overcome. For the correction of these difficulties, therefore, we must look to the engineers of the wire telephone companies. At present, the difficulties are, if anything, less than those met with in relaying on wire lines alone."

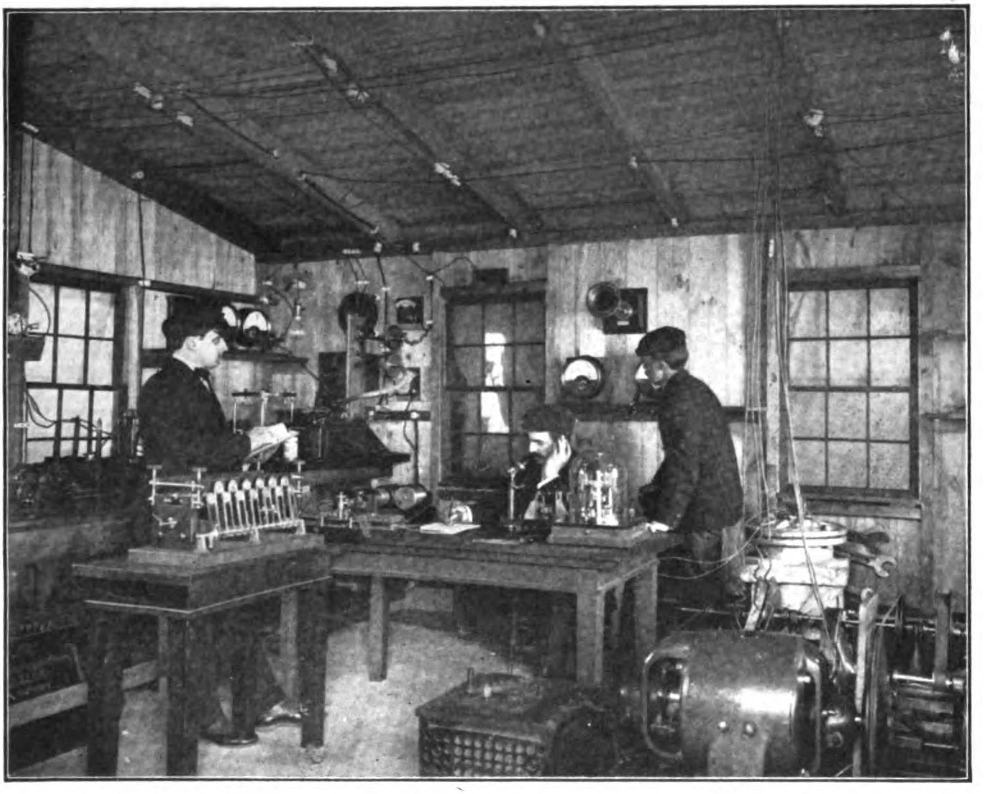


Figure 124—National Electric Signaling Company-Fessenden 2 K.W. radiophone transmitter

Another form of transmitter used by Mr. Fessenden is the condenser transmitter. This is not a carbon microphone at all, but a variable condenser with one (or more) fixed plates and one (or more) movable plates, the movable plates being brought nearer to or further from the fixed plates by the voice vibrations. In this way there are produced in this condenser changes of capacity closely proportional to the sound amplitudes. If such a condenser transmitter be connected between a high potential point of the antenna (e. g., the topmost point of the loading coil, L of Figure 125) and ground, it will have two effects when its capacity is varied by the sound waves. To begin with, it will detune the antenna by shunting the coil L and the radio frequency alternator A by a larger or smaller capacity (which capacity is, in effect, in parallel with the antenna capacity). This effect may be considerable if the antenna capacity is small, the antenna damping small, and condenser transmitter capacity variations large. Figure 126 depicts the curve of antenna current (ordinates) against frequency to which antenna is tuned (abscissas) with the alternator A run at con-

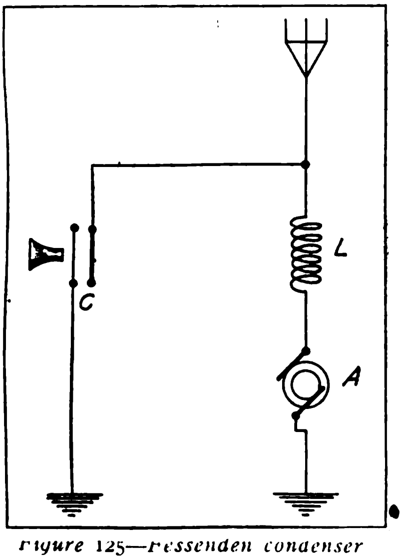


Figure 125—Fessenden condenser transmitter for radiophone work

stant frequency corresponding to the point *A* on the curve and the peak of the resonance curve. The proper point to work the antenna for such a system would be at some such point as *F* on one of the steeply falling branches of the resonance curve. Then, if the frequency were altered periodically between *OB* and *OD* by the condenser transmitter, the antenna current would similarly vary periodically between *EB* and *DG*. The second effect of varying the capacity of the condenser transmitter would be actually to "spill" energy from the antenna to ground through the transmitter capacity. These two effects should assist each other and the reader can satisfy himself by a little thought on the subject that this result can be secured by tuning the antenna system with the condenser transmitter in its undisturbed position to a *lower* frequency (that is, *longer* wave length) than that of the alternator. If the opposite is done, the two effects of the condenser may partially or entirely neutralize each other.

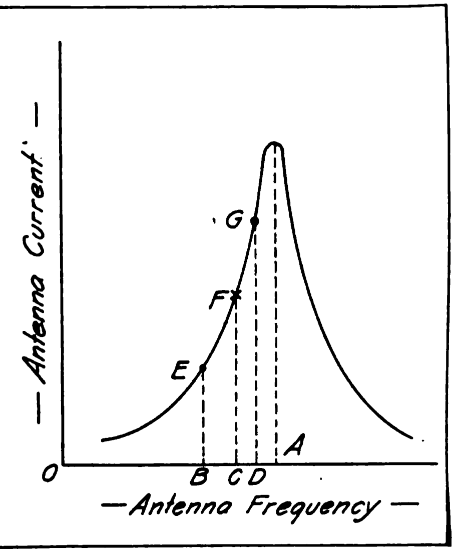


Figure 126—*Detuning characteristic of radiophone transmitter*

This is the tenth article of a series on "Radio Telephony," by Dr. Goldsmith. In Article XI, which will appear in the November issue, the consideration of high current microphones for modulation is continued. The type of telephone relay used by W. Dubilier is taken up and the high current transmitter used by the Telephone Manufacturing Company, that devised by C. Egner and J. .G Holmstrom and that used by R. Goldschmidt, are discussed. Methods of attacking the problem of high current microphones by using conducting liquid jets are also taken up. The article concludes with descriptions of radiophone experiments made by Dr. Alexander Meissner and those made by Mr. Round, of the Marconi Company.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of The Wireless Age, published monthly, at New York, N. Y., for Oct. 1, 1917.

State of New York, County of New York, ss.

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared J. Andrew White, who, having been duly sworn according to law, deposes and says that he is the editor of The Wireless Age, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Names of— Post Office Address—
Publishers..Wireless Press, Inc.,
42 Broad St., New York, N. Y.
Editor..J. Andrew White, 42 Broad St.,
New York, N. Y.
Managing Editor—None.
Business Manager—Alonzo Fogal, Jr.,
42 Broad St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

Wireless Press, Inc., 42 Broad St., New York, N. Y.

John Bottomley (851 shares), 233 Broadway, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

J. ANDREW WHITE,
Editor.

Sworn to and subscribed before me this 25th day of September, 1917.

(Seal) HENRY SAUBER,
(My commission expires March 30, 1919.)
Bronx County Register Certificate 141.

A Convoy to Ward Off Submarine Attacks

An Efficient Method for Protecting Flotillas of Cargo Carriers

By Professor Francis B. Crocker of the Crocker-Wheeler Company.

Professor Crocker is a former president of the American Institute of Electrical Engineers and was for twenty years head of the Department of Eelectricity at Columbia University. For many months he has been working on the submarine problem and the following article embodies his solution.

THE submarine problem is still unsolved. Every week brings its formidable list of vessels that have been sunk—every week lives are lost and almost priceless cargoes destroyed. Occasionally there is a week when fewer vessels than usual are sunk, and our hopes rise, only to be dashed by the increased number of sinkings the next week. Seldom do we know the full toll, for the published figures usually cover only British losses, which are not much more than half of the total of all nationalities, and are based upon that vague phrase, "over 1,600 tons."

As yet no sure way of catching and destroying submarines has been devised, and until an absolutely effective means is created, the world must remain powerless before the undersea menace to shipping.

Several serious flaws appear in the present theory of preventing the loss of vessels merely by destroying submarines.

First, comparatively few submarines can do a lot of damage. Second, there is the human tendency of officers and crews to think that a near shot is a hit, and that submerging is sinking. Even when a periscope is struck, allowance must be made for the fact that the larger submarines have two or more periscopes, the submarine is therefore not fatally hurt, and can cruise under water by compass, coming to the surface now and then to make observations or to repair the periscope. Experts agree that it is hard to tell whether the damage is fatal, and doubt whether very many submarines have so far been destroyed. Third, Germany can probably build them as fast or faster than they are being destroyed.

And as we await the perfected destroying agency, precious lives, ships and cargoes are being wasted.

In the scheme here described, however, nearly all the ships involved are protected from torpedoes by two parallel lines of overlapping nets, each of moderate length and towed by its own vessel. This vessel may be a cruiser or destroyer having sufficient power to tow its net at the ordinary speed of convoyed steamers, say at ten or twelve knots per hour.

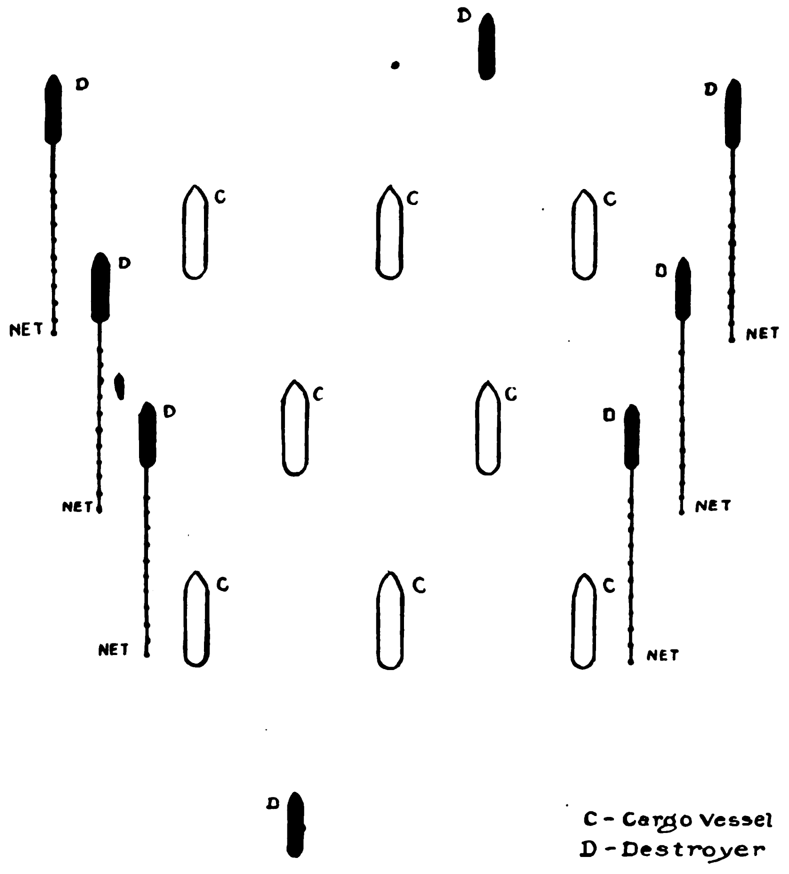
It is assumed that the merchant vessels and others needing protection from submarines would meet at a certain point outside the so-called danger zone, and when a sufficient number had gathered, would be convoyed to port.

For a vessel under way, especially on a voyage at sea, it is practically out of the question to protect it individually by nets, on account of the difficulty of supporting them. To give effective protection against torpedoes the nets around the vessel would have to be held out at a considerable distance from the hull, and the strain of dragging the nets along, especially if the sea were rough, would be enormous. The weight, cost and complication of the rigging required would be prohibitive. Moreover, the power of most merchant vessels is quite limited, and their ordinary speed of ten or twelve knots an hour would be reduced to a very low figure, seriously curtailing their efficiency as carriers.

In the scheme here proposed, a single net is towed directly astern, a method with which sailors are familiar. In bad weather there would be much less drifting and sudden, heavy strain on the towline than would be the case if one or several barges were being towed.

I have suggested nets 1,000 feet long and 25 feet deep, which is below the level at which torpedoes travel, for if the missiles' path were deeper than this they would fail to hit vessels of moderate draught, and would strike a glancing blow on most hulls of greater depth. Of course the nets may be made deeper, if desirable, or they may be varied in number and made longer or shorter than 1,000 feet, so as to be convenient for handling.

Each net is supported by a number of cigar-shaped buoys or floats of



sheet steel, but these need not be large or numerous to support the necessary weight of net.

By proper construction the power required to tow the nets may be reduced to a reasonable amount. Nevertheless, this power will be large and each net should be towed by a high-powered destroyer or cruiser. Such a vessel, without the net, would run twenty-five or more knots an hour. When towing the net its speed would be reduced to ten or fifteen knots, which is the ordinary rate of convoyed steamers, so that the whole fleet could travel at the full speed of the slowest vessel.

Vessels need be convoyed only through the danger zone, which is 200 or 300 miles wide, so that the time occupied would be about twenty-four

hours and a little slowing down for that period would not be serious. Certainly it is better than losing each week dozens of ships with cargoes. and many of their crews. At night, and in foggy or very rough weather, the formation of the convoy could be made more open, as the danger from submarine attack would be less.

Such a convoy would be formidable to a submarine for three reasons:

First, a line of nets on each side offers protection to nearly all the vessels, so that the chance of submarine attack is small.

Second, one or more destroyers or chasers, with full freedom of action, would be ahead and behind the fleet ready at the first indication of a submarine.

Third, other vessels of the fleet would be armed, so that shots from many directions would be concentrated on an attacking submarine.

Of course, all the ships would be on the lookout and therefore more likely to detect the submarine.

In spite of the general prejudice against convoys they seemed to work well in the recent sending of our troops to France.

One of the greatest difficulties in securing adoption, or even trial, of any plan is the fact that naval and scientific men—and, in fact, the public generally—expect an ideal solution of this most difficult problem. If mitigating methods, even though not 100 per cent. efficient, had been or were now being used, they would materially reduce the number of vessels sunk.

The fact that a torpedo fired at an angle of 45 degrees on either side could pass the nets either ahead or behind, might be an objection advanced to this scheme. It is obvious the nets may be extended further ahead or astern.

In the rear the opening is narrow and the vessels are going away, hence the danger is not so great. In front the convoy as a whole is very formidable and a submarine would not dare to take the chance of getting between the nets. Furthermore, at a distance, especially at an angle of 45 degrees, accurate shooting with a torpedo would be almost impossible. Torpedoes are usually fired as nearly as possible at right angles to the length of the ship to be attacked. Otherwise they strike a glancing blow and slide off or fail to explode. A net loose in the water, not stretched between supports, need not be so very strong to arrest a torpedo, for the same reason that a hanging cloth which will stop a moving body would be penetrated if stretched taut on a frame.

MARCONI'S BELIEF IN OUR INVENTORS

Guglielmo Marconi is quoted as having said on his arrival in Paris from this country that the United States will accomplish much to subdue the submarine.

"The Naval Consulting Board is not working vainly," he declared. "While no decisive means of combating the menace has been found, I have seen proved means of defence becoming daily more efficacious.

"The danger from submarines is decreasing daily. It is certain that future losses will diminish and thus Germany will first feel America's weight in the great war.

"I have seen many other amazing things in the American scientific domain, of which I cannot speak, but which will help us perceptibly toward the actual ending of the war. These things are now at the Allies' disposal."

It has been announced that in order to provide for what are known as "life and death" telegrams without disclosing the location of ships of the Navy, orders have been issued to all naval men directing then to inform their families that messages of the character mentioned are to be forwarded addressed to the ships in care of the Bureau of Navigation at Washington, D. C. These messages, it is understood, will be sent to the ships in many cases by wireless.

CAPTAIN FRITZ E. UTTMARK, NAVIGATOR AND EDUCATOR

FRITZ EMMERICK NILSON-UTTMARK, navigator and educator, was born September 4th, 1871, in Gothenburg, Sweden.

His father, a prominent merchant, doing business in Gothenberg under the name of Fritz Nilson & Co., and a man of excellent social standing, failed in business during a panic about 1884. He was one of the founders of the Royal Swedish Yacht Club.

Captain Uttmark was educated in Schiller's private college in Gothernburg, but his father's failure in business compelled him to leave college without receiving a degree. He entered a business firm in Gothenburg, and finding that pursuit distasteful, went to sea as an apprentice on the bark Gladon. He entered the Government navigation school at Gothenburg in 1890 and was graduated the following year. After he had obtained his certificate of competency, he was engaged as a navigator, being officer of several vessels sailing on all oceans. In his time he sailed under the Swedish, Norwegian, Danish, German, British, French, Chinese, Russian, and American ensigns.

He spent several years on the coast and in the interior of China. He was in command of several steamers there for a time, and later rceived an appointment as chief of a marine department in which capacity he organized a transportation service and constructed an adequate line of steamers, tugs, barges, pontoons, and wharves, in connection with important Chinese collieries and iron mines. He had headquarters at Hankow, with branches at various points on the Yangtse and An rivers.

Captain Uttmark passed examination for and obtained a British master's license at Hong Kong in 1903. He made various trips to the United States, but it was not until 1911 that he finally came here with the purpose of making the United States his permanent home, and became an American citizen.

His education and varied experience had endowed him with an excellent knowledge of navigation, and he determined to utilize this knowledge by teaching. He has since 1911 been teaching navigation, becoming proprietor of what is now Uttmark's Nautical Academy. Founded in 1882 by Captain Howard Patterson, and known successively as Patterson's Navigation School and New York Nautical College, the present name was adopted when Captain Uttmark became its proprietor. It is said to be the oldest nautical school in the United States.

Captain Uttmark is author of Uttmark's Guide to Examination for Masters and Mates and the Uttmark System of Navigation and Nautical Astronomy, and he is owner and editor of Uttmark's Nautical News. He is a member of the American Shipmasters' Club of New York, the Marine Transportation Association of New York, and the National Geographic Society of Washington, D. C. He is a fellow of the American Geographical Society.

His sea experiences would make an interesting book. During the Russo-Japanese War, he commanded the steamer Samson, having on board Bennett Burleigh, the famous war correspondent.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

AMERICA has at last awakened to the urgent necessity for an adequate merchant marine, and as a result activities in her shipbuilding yards are greater than ever before. In past years the Yankee clipper-ship was known the world over and acknowledged to be superior to all others; the American flag was seen in every port of any importance on the seven seas, and the growth of many one time obscure places is due to the fact that they were visited by American vessels. The American skipper was known for his ability and zeal in navigating his ship, which enabled him to make the smartest passages from West to East and from East to West.

Later on, however, the merchant marine of this country fell into a period of comparative inactivity and other nations assumed the leadership of the seas.

Since the beginning of the world war the United States has felt the immediate need of strengthening her over-sea traffic in order to facilitate the transportation of her goods and passengers on her own bottoms. America requires ships and officers and men to handle the vessels. Consequently there are now excellent opportunities for able, clean cut young men to enter a profession that has many advantages.

To those who contemplate choosing the sea for their life work the following information will be of interest: The law calls for two years' experience in the deck department of steam or sail vessels before any candidate will be examined for a third officer's license; three years' experience is necessary in order to be eligible for a second officer's license. After that, with additional experience as junior officer, step after step is taken until a captain's license and command of a vessel are obtained.

As no headway can be made in navigation without a thorough knowledge of the subject, a series of articles for THE WIRELESS AGE has been written for those ambitious to study the problems which confront the practical navigator. This is the first article of the series.

CHAPTER I

Definition of Navigation—List of Instruments, Charts and Books Used by the Navigator.

DEFINITION

NAVIGATION is the science that teaches us to determine our position at sea and to conduct the ship from place to place; it consists of two parts, **Navigation and Nautical Astronomy.**

Navigation, according to the first term, enables us to determine our position by reference to the earth and is further subdivided into *a. Piloting* or *Coasting* when position is obtained by reference to visible objects on the earth or from soundings of the depth of water and the nature of the bottom; *b. Dead Reckoning* in which the ship's position is deducted from courses steered and distances run from a given point of departure.

Nautical Astronomy. This term is used for that part of the science which enables us to determine the ship's position by observations of the celestial bodies—the sun, moon, planets and fixed stars.

INSTRUMENTS

The necessary instruments, books, etc., used by the navigator are as follows:

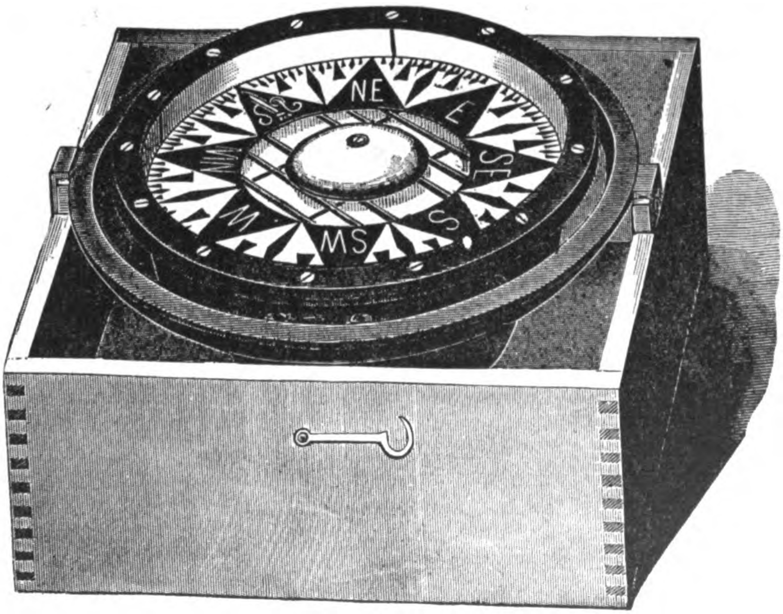
The mariner's compass, charts for the waters to be navigated, parallel rules, compasses or dividers, log and logline, log glass, lead and lead line, sextant or octant, chronometer, pelorus, sounding machines, binoculars, barometer, thermometer, bowditch useful tables, nautical almanac and azimuth tables.

CHAPTER II

The Mariner's Compass—Its Construction and Use

THE compass is the most important instrument used by the sailor and its principles and construction should be familiar to every navigator, whether he sails a small boat along the coast or navigates the largest steam or sail vessel across the ocean.

The mariner's compass consists of a non-magnetic metallic bowl in the center of which is fixed a pivot. A magnetic needle, or generally several pairs



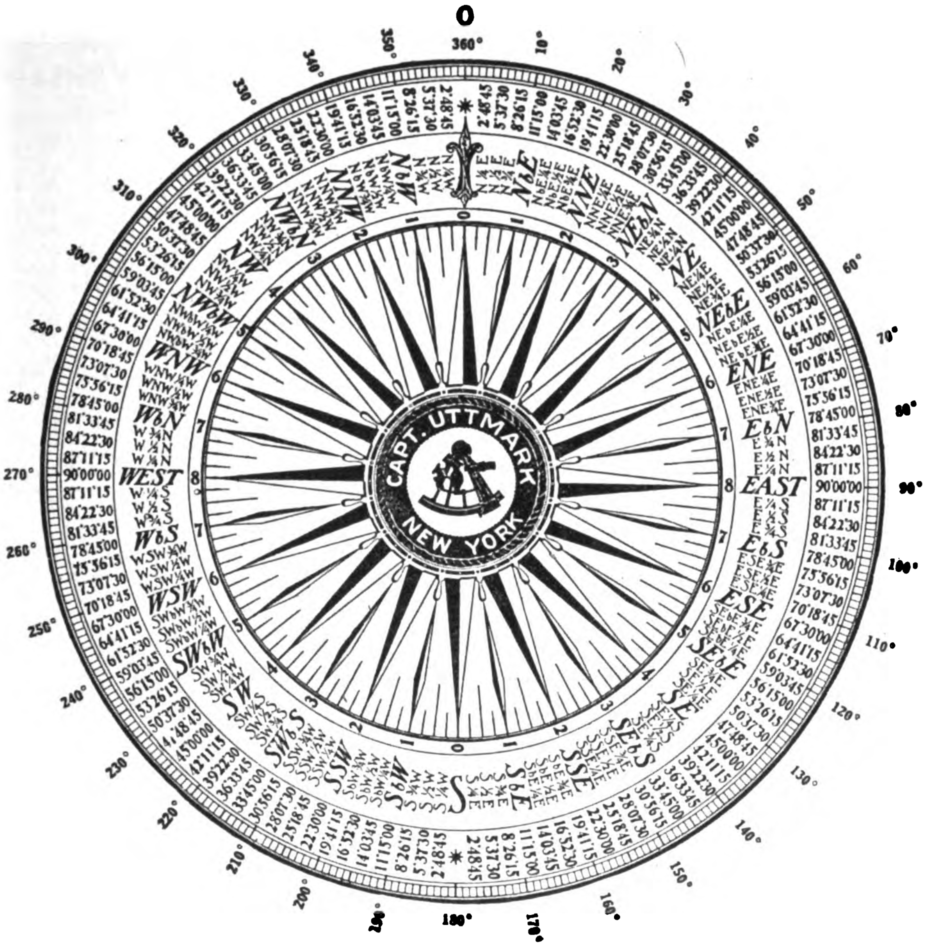
Compass card

of needles, parallel with one another, are so centered and balanced on the pivot that they can freely swing in the horizontal plane and undisturbed by proximity of iron will come to rest in the magnetic meridian. A graduated card is fixed to the needles in such a position that the *North* marked on the card will point to the magnetic North pole on the earth. The ship's course is measured by this instrument, and bearings of objects on land as well as amplitudes and azimuths of the heavenly bodies are measured.

The compass card is a circular disc the periphery of which is divided into 360 equal parts called *degrees* or in 32 equal parts of 11° 15′ each called *points*. These points are again subdivided into half points and quarter points. The compass card, as seen in an accompanying illustration, shows the various systems.

The process of naming the compass points in their proper order is known as "boxing the compass." The newest and most convenient way of numbering

the degrees is from 0 (North), increasing righthanded up to 360 degrees. This system is now in use in the United States Navy and if universally adopted would be of great benefit and convenience to all navigators.



Mariner's compass

In the merchant marine, however, the older systems still prevail. North and South are here considered as zero (0°.) marks, East and West as 90 degrees. Intermediate degrees are read from the zero points, as for instance, midway between North and East would be N 45° E; midway between South and East S 45° E and so forth.

The oldest system which is still extensively used, on account of being most complicated should be memorized first of all. The card is divided into its thirty-two points with subdivisions. The four main points, North, South, East and West, are called the cardinal points; each one is at right angle or eight points from the adjacent one. Midway between these are the inter-cardinal points, which are named Northeast, Southeast, Southwest and Northwest. It is four points or forty-five degrees between each cardinal and the adjacent inter-cardinal point.

Beginning with North, the thirty-two compass points are named as follows: North, North by East, North-North-East, Northeast by North, Northeast, Northeast by East, etc.

In boxing the compass in half and quarter points, it is the custom in the United States to refer to these as follows: North quarter East. North half East. North three quarters East. North by East quarter East, etc.

The three systems are shown in tabulated form which also is conveniently used in converting one system into another.

CONVERTING POINTS INTO DEGREES AND VICE VERSA

Points	Old System	New System	Points	Old System	New System
North	0	0	South	0	180° 00′
N by E	N 11° 15′ E	11° 15′	S by W	S 11° 15′ W	191° 15′
N N E	N 22° 30′ E	22° 30′	S S W	S 22° 30′ W	202° 30′
N E by N	N 33° 45′ E	33° 45′	S W by S	S 33° 45′ W	213° 45′
N E	N 45° 00′ E	45° 00′	S W	S 45° 00′ W	225° 00′
N E by E	N 56° 15′ E	56° 15′	S W by W	N 56° 15′ W	236° 15′
E N E	N 67° 30′ E	67° 30′	W S W	S 67° 30′ W	247° 30′
E by N	N 78° 45′ E	78° 45′	W by S	S 78° 45′ W	258° 45′
East	N/S 90° 00′ E	90° 00′	West	S/N 90° 00′ W	270° 00′
E by S	S 78° 45′ E	101° 15′	W by N	N 78° 45′ W	281° 15′
E S E	S 67° 30′ E	112° 30′	W N W	N 67° 30′ W	292° 30′
S E by E	S 56° 15′ E	123° 45′	N W by W	N 56¼ 15′ W	303° 45′
S E	S 45° 00′ E	135° 00′	N W	N 45° 00′ W	315° 00′
S E by S	S 33° 45′ E	146° 15′	N W by N	N 33° 45′ W	326° 15′
S S E	S 22° 30′ E	157° 30′	N N W	N 22° 30′ W	337° 30′
S by E	S 11° 15′ E	168° 45′	N by W	N 11° 15′ W	348° 45′
South	0	180° 00′	North	0	360° 00′

¼ point = 2° 48′ 45″ or approximately 3°
½ point = 5° 37′ 30″ or approximately 6°
¾ point = 8° 26′ 15″ or approximately 8°

(To be continued)

ELUDING SUBMARINES BY THE ZIG ZAG METHOD

Zig-zagging by commanders of vessels to elude attacks by submarines has a protective value which it did not possess before merchant ships were armed. Now that the tramp is apt to carry a rapid-fire gun of from three to six-inch caliber, the U-boat, once it has come within the effective range of the gun, must stay below. In the old days, a submarine with fourteen to seventeen knots speed, did not hesitate to run down its prey on the surface, and a large proportion of the victims were sunk by gun fire. But when merchant ships began to mount powerful guns with Navy-trained gunners behind them, the sinking, even of slow tramps, became a very difficult and hazardous task.

On sighting an approaching ship the submarine heads to intercept her course, submerges, and then takes an occasional look at her, bringing its periscope above water for a few seconds only. The U-boat commander estimates the speed and course of the ship, submerges and lays his own course by compass while below, so as to bring his boat within torpedo range, preferably forward of the beam.

Now, if while the submarine is below, the merchant ship changes her course, say through an angle of forty-five degrees, the former, on coming up for a few seconds' look at the ship, finds that, instead of converging to meet him, the merchant ship is sailing in a direction entirely different from that on which his calculations were based; his manoeuvre for getting into firing position goes for nothing, and he has to try again. Unless he is satisfied that his guns can greatly outrange the enemy, the U-boat commander does not dare to use his surface speed, and below the surface he has not sufficient speed to overhaul the merchant ship. One or two misjudgments of this kind will lose so much time that the ship will have a good change to pass him and steam beyond torpedo range.

"All in a Day's Work"

The Story of an American Operator who Sailed on the Steamship Navajo, Met and Vanquished a Submarine and Nearly Lost His Life in a Fire a Thousand Miles From Shore

By **CLARENCE CISIN**

TO the crew of the Navajo the Fourth of July came in like the proverbial lamb and went out as a roaring lion. And, incidentally, with a display excelled by no old-time celebration of that glorious day.

The sun was shining on a placid stretch of ocean that had all the peace and quiet, if not the exact aspect, of a street scene in Flatbush. Dinner was in progress and one of the men remarked that it didn't seem at all like the national holiday without the time-honored fireworks—

Had he been a prophet, gifted with the true foresight, his name would go down in history as the world's joker—

Almost immediately the alarm gong rang out its warning.

With a few choice words regarding the visions of over-zealous lookouts—for the pie was particularly appetizing—we rushed out on deck. And there was a submarine off our quarter, looking very business-like, with its gun crew on deck preparing to fire on us. The Captain immediately rushed to my cabin with the ship's position and my key snapped out the distress call instanter. A British destroyer answered, reporting that she was speeding toward us. Our gunners opened fire upon the "Sub" and after three shots from our guns she submerged. Whereupon we breathed a sigh of relief and anxiously awaited developments.

The patrol overtook us about an hour later, and convoyed us a short distance.

That night the machinations of submarines was a topic very seriously discussed. . . .

So was life insurance.

Early the next morning, July fifth, I was awakened by the sound of shots. The Captain came to my cabin and asked if I could hear any distress calls. I listened in, and picked up a distress call from a British ship, saying that she was being shelled by a submarine. In the middle of her message, as she was stating her position, the spark suddenly died out. It was a tense moment, as will be understood by all operators who are familiar with the peculiar appealing sound given out when an accident occurs to the transmitter.

Nothing more was heard from that ship. Then those on deck reported that a sailing ship about three miles ahead of us had apparently been struck by a shell, as she buckled midships and almost immediately went down.

Half an hour later the submarine appeared and commenced to chase us. I sent out our S O S and established communication with a French land station. The chase was well on when, a little over an hour later, an airplane came speeding toward us—it gave us the kind of a feeling a drowning man must have when he suddenly finds a life-preserver floating toward him. The plane circled round us and the U-boat promptly submerged. We no longer felt that the newspaper talk about submarines had been exaggerated.

Somehow or other, there was not a great quantity eaten at the noonday meal, despite the fact that we expected to arrive at the Port of Havre within a very short time, and all felt that the worst was over. But the subject of U-boats is one not given to easy speculation.

We were going full speed ahead, and although a heavy fog had arisen, the engineers kept the ship at its top. We were not breaking any "speed records" at that, for about nine and a half knots was our ship's best, even when pushed to the limit.

About three o'clock the same afternoon the fog lifted. There on our starboard side, a little over two miles away, was the ominous "Sub" with her gun crew on deck, ready to fire. They didn't lose any time about it, either. A peculiar whizzing, shrieking sound was heard, and a shell exploded about ten feet from us. A blue flame and a sickening thud—the whole ship rocked. The Captain immediately swung our ship around so that the stern of the vessel faced the submarine; then we opened fire.

I had started the distress call immediately upon sighting the submarine, adding the ship's position, which the first mate brought in a few minutes later. The wireless cabin was directly back of the after gun, and presented an excellent target for the U-boat. Shells were flying in all directions. One shell whizzed directly above my cabin, miraculously missing the masts of the ship, and landed a few yards ahead of us. Another shell exploded at about ten feet from one of the windows of my operating room, and a shower of water was thrown all around and upon the apparatus.

In the meantime I had picked up two British destroyers and a French land station. The destroyers sent encouragement, stating that they were steering toward us.

We expected to be struck any moment and we all knew that one shell would mean good-bye. For it would not only completely disable the Navajo, if it struck anywhere near the engine room, but would immediately set fire to the oil which we were carrying for fuel.

The battle lasted about fifty-five minutes, during which time the naval gun crew went about their business in the coolest manner imaginable. One young lad named Smith, a gun pointer, kept repeating, even with the shells bursting on all sides of us: "Those damned Germans can't hit us. Yeah! Give it to 'em, boys!" Our third mate had joined the gun crew and gave very valuable assist-

ance. The trigger of the gun was out of order and he worked the lanyard which they had attached to it.

I realized that if one shell struck my cabin, pieces of wireless apparatus and wireless operator would be spread promiscuously about the ship. It was sort of comforting to realize that this separation would be instantaneous. Long before we entered the war zone I had decided just exactly what my procedure would be in case we were fired upon, but I little realized that, in place of self-preservation thoughts, there would come to me an overwhelming sense of duty to our glorious country, which would keep me at the key while it seemed every moment would be the last. I cannot see my action in a heroic light, for I stayed on the job without a thought of anything but the matter in hand. There must have been a guarding Providence watching over us, at that, for though shells were flying over and around us, missing us by a few feet, they *did* miss.

The twenty-fifth shot had been fired when the men, watching with every nerve strained, saw an explosion take place directly above the conning tower. Several of the enemy crew were seen leaping into the water as the submarine up-ended and sank. They had fired altogether twenty-three shells at us, and we fired twenty-seven.

When the guns ceased firing, the silence was just as it might be had you been standing close to Niagara Falls, and the falls were suddenly turned off. So great had been the vibration in my cabin the detector point had been jarred from the crystal several times during the battle. But we were through it successfully, and ready to call it "a day."

Then, just as all hands were breathing a sigh of relief, and I was about to light my pipe, the first mate rushed into the cabin and said, "Continue the 'distress,' another submarine is in sight!" There was to be no rest for the weary.

The engineers used all their energy in making the utmost speed, and the submarine which we had just sighted submerged within a few minutes. But not before one of the fragments of a shell had struck the stern of our ship, almost directly below my cabin, but above the water level. This required seventy-nine rivets when we arrived in France.

As I see the battle now, it is clear that with all the seriousness of the situation, there were still quite a few humorous incidents taking place while we were under fire.

Our carpenter, a Portuguese, when he heard the first shell whizzing by, looked out from the forecastle head and said "Sooter-marine!"—immediately thereafter disappearing. About three minutes later he appeared on deck, carrying his clothes done up in a bundle in one hand; a pair of old dilapidated shoes were dangling from the bundle and his set of tools were held in his other arm; his mattress was half slung over his back—he had everything but the piano. Thus encumbered, he rushed toward one of the lifeboats; but the first mate, seeing him from the bridge, ran down and grasped him by the collar, at the same time delivering some extremely well-aimed kicks, and saying, "I am spoiling a new pair of shoes kicking you!"—*bam! biff!*—"and if we get through this alive,"—*thump!*—"you will have to pay for them out of your wages."—*slam!* "Now get below, blankety-blank you, and help pass up ammunition!"

Another incident serves to illustrate how the habits of a lifetime dominate the excitement attending emergencies. When the first shot was fired, the first assistant engineer went below to call his chief, who had turned in for a nap. He drawled lazily, "I guess maybe you'd better get up, sir, we're being shelled by a submarine," while outside the cabin could be heard the Japanese, whom we had on board as steward, messmen, etc., running wildly from one cabin to the other in great excitement, and kissing each other fond farewells.

We arrived at Buxham, England, the same evening and anchored in the stream. A report of our encounter had preceded us and we were visited by

several of the British officials. Later we received a letter of congratulation from the British Admiralty for sinking the U-boat.

That night we all sat around "chewing the rag" until about midnight. Had it been a religious gathering, it would not have been possible to have collected a more subdued and serious group of men; most faces bore an expression of heartfelt thankfulness for our miraculous escape.

About midnight we bade each other good night, apparently to turn-to. I went out on deck to have a final smoke before retiring, and about ten minutes later the third mate appeared, followed by two of the engineers; and there, before half an hour was up, we were all seated on deck, discussing the battle again.

The next evening we crossed the Channel with four other ships bound for Havre, and under the escort of a convoy. We arrived at Havre the following morning without further incident, and remained in that port a little over a week. During that time I had occasion to travel to Paris. There were about "fifty-seven varieties" of police inspectors who found it necessary to look at my passport and papers and it seemed as if everything and everybody was in uniform. A vast number of Americans, mostly from the Medical Corps and the Engineers Division, were in evidence. A civilian created as much curiosity as a man in uniform had had bestowed upon him a few years before the war.

Women were working as street cleaners, taxi-drivers, car conductors, and at practically every vocation of men in peace time. There was a ratio of about forty women to every man. Particularly pleasing were the car conductors, with their "kippy" little white hats and neat uniforms; a sight that would have cheered the pastels and paints of Howard Chandler Christy.

The French people surely know how to make strangers feel at home. A little incident of my train trip to Paris may be interesting, to show the attitude of all French people toward Americans. In the compartment in which I was riding there was a French soldier just returning from the front and a young lad who was studying aviation. They spoke very little English; my French was not quite as good; but we were able, by means of signs, gestures and a French-English dictionary, also by drawing little sketches, to converse with each other. I believe it was the best example of the pantomimic art on either continent—bar none.

When they grasped the fact that we had sunk a submarine, the soldier exclaimed, "Ah! *Americane!* My comrade!!" And he produced a bottle of wine from his kit. After which we were all little comrades together.

On July 14th, France's great national holiday (the fall of the Bastille) an immense review of the troops of the allied countries was held, headed by President Poincaire. Everyone for miles around who could secure a pass for the railway trip came to Paris for this event. The soldiers of the various countries marched by amid cheering and flag-waving of a spine-thrilling order. "Old Glory" was very much in evidence. I noted particularly, however, that among the soldiers were a great many lads apparently between the ages of seventeen and twenty, and, although the occasion was one of great celebration, there appeared a tired, dissatisfied, sort of longing-for-the-war-to-end expression on the faces of the majority of them.

When we sailed from Havre, we were acting as a convoy to twenty-three merchant ships. The Navajo steamed proudly ahead of this large procession, looking as if she were leading an exciting race—a thought which, however, immediately vanished when we remembered our unimpressive speed of eight and a half knots.

The next day we arrived in Fowey, England. Fowey is, indeed, the garden spot of the world. There are a hundred and one little nooks, shaded by gorgeous flowers, and the greenest of green trees, sending alluring invitations to all lovers of nature. All about are miniature hills, with dreamy bungalows perched on

the summit, overlooking a stream dotted here and there with "skippy" little sail-boats drifting along in a carefree, lazy fashion. Fowey would make a poet out of a Coney Island sideshow "barker."

We left this port with the whole town lined up to bid us farewell. The second day out, about 4 a. m., just as I was coming off watch, we sighted the body of a man lashed to a mast. The corpse was floating quite near us and the form was withered and apparently eaten away. It seemed like an ill omen.

The next morning at 5 a. m. we sighted a crowded life-boat. The people in it were waving to attract our attention. We overtook it, and saw twenty-three men—thirteen Chinamen and ten Englishmen. As we steamed past, they looked up at us with a pitiful imploring sort of expression as if they feared we would not stop for them. We did, however, and took them aboard, when we learned that they were from the British ship Glenstrae, torpedoed the evening before at about 9 o'clock.

The Captain immediately gave me a code message, asking that one of the destroyers relieve us of these men as we had but three life-boats, a number sufficient only for our own crew. I got in touch with a British patrol, and within a couple of hours it was alongside and took the shipwrecked men away.

A few days later, on August first, we had just about cleared the war zone. All hands were beginning to lose that strained constantly alert, half expectant, half dreading, expression that marks men who have reason to hold the sub-marine in great respect. A few of the men had decided to undress the next time they went to sleep. Someone even started a song about old New York town, and everyone joined in heartily. The spirits of the third mate rose and he washed his laundry which he had let accumulate since the beginning of the trip, because, as he said, "Clean laundry and 'dirty' subs are a poor combination."

Then it happened!

I was taking my noon siesta, and was suddenly awakened by sounds of running and confusion and shouting along the deck. Luckily, I had only to put on my slippers and rush out on deck to find out the trouble.

One glance was enough. The after-part of the ship was a dense mass of smoke, with flames shooting up at frequent intervals. Everyone was shouting, and running up and down. Someone said, "Try and heave that ammunition overboard." (We had 110 rounds of ammunition for our three-inch guns stored away, and about 2,000 rounds of machine-gun ammunition in my operating room.) The Captain bellowed down from the bridge, "Send out the S O S!"

I started the generator and one of the oilers came rushing in. "Sparks, the fire is uncontrollable," he shouted. "Keep the 'distress' going!"

I was already shooting it out, saying, "Ship on fire. Burning oil."

The fire was gaining such rapid headway that within five minutes the flames were licking in the windows of my operating room. Suddenly the curtains burst into flame. We had three life-boats on the after-poop outside my cabin, and they were being lowered away. It was impossible for any of the engineers to get below to the engine room, because of the fire and smoke, and the ship was going ahead full speed. I was still repeating the "distress" when I heard through my open window one of the naval lads shouting, "We're leaving, wireless!"

I was stunned for the minute. Then I grasped the import of that sentence. I grabbed the pup and ran from my cabin. Two of the boats were already away from the ship. I slid down the falls just as they cut away the last rope.

It was only good luck that kept us from capsizing, for the Navajo was going ahead full speed. But somehow we managed to get clear and rowed away from the swirl created by the propellers.

The fire had gained such headway that the whole poop was now a mass of flames. We were approximately 1,000 miles from land, and in an entirely un-used ocean track and the only sign of a ship we had seen in the past four days

was the patrol boat that had relieved us of the Glenstrae's survivors. It seemed probable that some time would pass before we stood any chance of being picked up.

These facts I had just grasped when the shells began to explode! First the ammunition for the rapid-fire gun went off with staccato reports; they sounded very much like the automatic trip hammers used in steel construction work; then came the deep boom of the large shells, followed by the peculiar whizzing sound as the projecticles shot out.

The whole after-part of the ship was one sheet of roaring flame and we expected to see the boilers go at any moment. The life-boat which I was in was in charge of the second mate; we also had the second assistant engineer and eight of the Portuguese crew. We knew that we had to make a quick get-away so everyone took a hand at the oars, everyone, that is, except one big Portuguese fireman. He was a man who must have been born on a rainy day; his ugly, crabbed nature had made him very much disliked while on shipboard; he had lost one eye in some manner, and the other eye had a ferocious, animal gleam in it; and there he sat, lounging back like a passenger, watching the rest row. I suggested to the second mate that this fireman relieve the second assistant engineer, who was an elderly man; and the second mate ordered him to do so. The fireman scowled, and replied, "No savvy." He savvied as well as anybody, but probably the combination of fright, laziness, and natural meanness, made him refuse.

I could see the second mate inwardly boiling with rage; he did not have his revolver with him, so in whispers he planned with me to use the end of an oar upon the fireman's head. A life-boat is no place for excess baggage, and this man was setting a dangerous example to the other Portuguese. We had but a limited amount of water and hard-tack aboard, and it was necessary to maintain strict discipline.

So, following instructions, I began edging over toward him with the intention of grasping his arms while the second mate utilized an oar on his head—when we saw the smoke of a steamship in the distance.

All grievances were immediately forgotten in the joy of the sight. No words can express with any degree of justice the feeling that ran through us.

Within an hour we were all safely aboard. The vessel which rescued us was the Greek steamer Iossifoglu—some name to pronounce, but a joyous sight for us, you can bet. We all felt like giving three cheers for Greece and all things "Greecy."

There were two American firemen aboard, and their first remark was, "Well, you sure have struck a hungry ship." And they were right. Meals consisted chiefly of potatoes and tea, with variety injected by reversing it to tea and potatoes. But we did not look a Greek horse in the mouth, for, compared to hard-tack and water, the menu was indeed sumptuous.

I had a bunk above a Greek steward. He had, marching back and forth along the walls and over the bunks, the greatest collection of trained animals it has ever been my misfortune to encounter. Apparently they did not annoy him in any way, but I firmly believe that he must have spent considerable time in drilling them, as they would stand at attention, form in fours, fix bayonets and charge.

All through the first night aboard I occupied myself by striking the wall with resounding whacks. I connected with and killed the enemy—sometimes . . . . but not once did I miss my cuss phrase. About 2 a. m. the poor Greek steward knocked on my bunk and said, "What you mean, 'gol damn, gol damn' all night? What you mean?" I explained briefly, but to the point.

The next day we had a general hunt for shoes, socks, underwear, and various articles of wearing apparel, as some of us were shy everything, and

most of us required something. We were bound for Limerick, Ireland, which was comforting, as was the fact also that the Greek ship was a neutral one. We did not feel very much uneasiness while going through the "zone."

On August fifth we steamed up the River Shannon, where the country is rugged, hilly and green, with a scattering of thatch-roofed huts dotting the hill-sides. We arrived at our destination in the evening and once again we were very much touched by the hospitality shown us.

The far-famed ready wit of the people is indeed justified. One of our men, while getting a shave was cut, and angrily asked the barber why he didn't learn his business, whereupon the tonsorial artist replied, "Kape your mouth shet, if you want to be shaved. Shure 'tisn't my fault if your face is made wrong."

The waiter in our hotel would have been called an exaggerated type on any vaudeville stage. Upon being sarcastically informed that he was never born to be a waiter, he replied, "Sure and I knew that long ago. I was born to be a Prince, it's only circumstances that makes me a waiter."

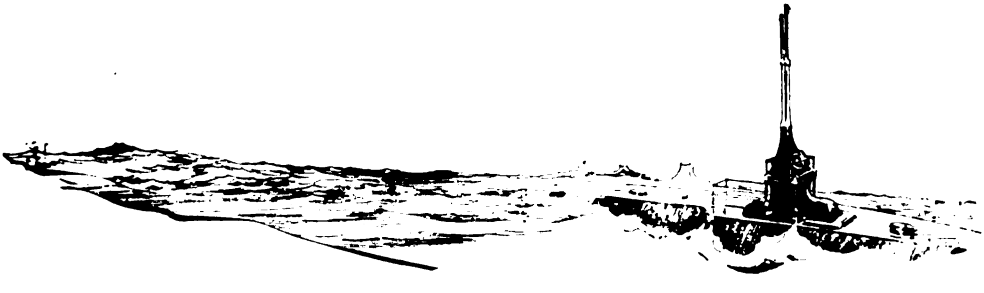
After seven days we left Ireland and sailed from Liverpool on the American liner New York, arriving at an Atlantic port in the United States without incident.

I have just received a letter from a wireless operator at the land station at Bleville, France. I met this chap while in Havre, and as he had picked up our distress calls we had quite a feeling of intimacy. His letter reads:

> My dear Mr. Cisin:
>
> I'm really happy to have the honor to know you, but very sorry that you did not stoped a long while to Le Havre.
>
> I think that was not last times see you, it will be for another.
>
> Don't wish receive any S. O. S. of S. S. 'Navajo' like this on the last 5 July at 11 a.m. and 4 p.m. (Very constantly)
>
> Your devoted new friend.
>
> (Signed) H. C.
>
> P. S. Excuse, please, my America writing, it is my first letter of this language.

The owners of the steamship company have mailed me a very liberal gift, accompanied by a kind letter of appreciation, and everything has ended very happily.

Maybe I'll have another story for THE WIRELESS AGE soon, for I expect to be on my way across again within a short time. Because of the necessity of supplying our troops with food and ammunition, the game is worth the candle.



Signal Officers' Training Course

A Wartime Instruction Series for Advanced Amateurs Preparing for U. S. Army Service

FIFTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

IN preceding articles of this series, the reader has been given the principles of individual drill instruction for the recruit and the marching evolutions of the squad.

On the assumption that the Signal Corps units following this course are not yet recruited to full numerical strength, so that drill regulations by section and company can be employed, instruction in signaling by flag is the next logical instruction step.

Communication of military intelligence by hand flags is best taught in squads or small groups. Recruit instruction should begin with the two-arm semaphore, using the flags illustrated in the lower portion of the drawing.

The following extracts from "Military Signal Corps Manual" will be found of value in learning two-arm semaphore flag signaling.

Hand flags are authorized for general use by the Army, though on account of their small range they are of limited application and are chiefly serviceable for use within organizations, within fixed positions, or for incidental signaling. The range with flags of the usual size is of course dependent upon light and background, but it is seldom more than one mile with the naked eye. This system of signaling has been highly developed in the Navy, and on account of its rapidity and simplicity is of use to the Army and should be familiar to all soldiers. It is limited to visual signaling work and not adapted to general signaling as is the General Service Code. It will be found useful under many circumstances and is adapted to special work when rapid communication for short distances is needed. This method is also used

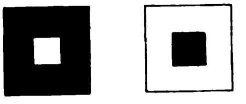
to advantage for interior signaling within batteries of the field artillery and within regiments of infantry, and at times is convenient to the cavalry.

The semaphore hand flags for service use are 18 inches square divided diagonally into two parts, one of red and the other of white;* the staffs are 24 inches long.

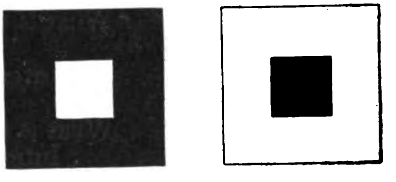
The hand flags of the Navy are from 12 to 15 inches square, of blue with a white square, or red and yellow diagonally, the colors to be used depending upon the background. The flags are usually attached to a light wooden staff about two feet in length.

In calling a station, the signalman faces it squarely and makes its call. If there is no immediate reply he waves the flag over the head to attract attention, making the call at frequent intervals. When the sender makes "end of the message" the receiver, if the message is understood, extends the flags horizontally and waves them until the sender does the same, when both leave their stations.

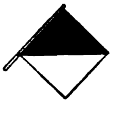
SIGNAL CORPS TWO FOOT FLAGS



SIGNAL CORPS FOUR FOOT FLAGS



SEMAPHORE HAND FLAGS



Recruits should be taught that the letters of the alphabet and conventional signals shown on the accompanying plates are indicated by definite positions of the arms and that these must not be assumed carelessly. An excellent plan of instruction is to face the beginner toward a clock or a disc divided into seven parts. The eight radial positions for the flags are then indicated by the clock's hour hand at 6:00, 7:30, 9:00, 10:30, 12:00, 1:30, 3:00 and 4:30 o'clock. The flags are moved in the same direction as the hands of a clock.

The method of instruction varies with the teacher, but a schedule which has worked out satisfactorily for the writer in teaching novices quickly is a division of the alphabet into sections as follows: (1) Letters A to G and numerals 1 to 7 inclusive; when these have been thoroughly mastered instruction is begun on (2) Letters H to N (omitting J) and the numerals 8 and 9; the instruction then being pursued in the rotation following: (3) Letters O to S inclusive; (4) Letters T U and Y; (5) Letters J and V and numeral 0; (6) Letters W, X and Z.

Contrary to the usual instruction in code telegraphing, flag signaling progress is more rapid if the beginner learns to receive first. If he starts his instruction with sending he has an opportunity to stop and think of the letter before taking the position. When facing a skilled signalman, however, the letters must register instantly on his mind or the message will be lost.

As the letters of each division in the six given are made familiar, simple words should be signaled containing these letters. When the alphabet has been completely covered, words may be expanded into phrases and gradually

*For the field and the coast artillery there has been temporarily issued a semaphore hand flag of orange with a scarlet center and scarlet with an orange center, one of each constituting a kit. The flags are 18 inches square, the centers 9 inches square, and the staffs 24 inches long.

into sentences and complete messages. The soldier should then become familiar with the letter codes which follow:

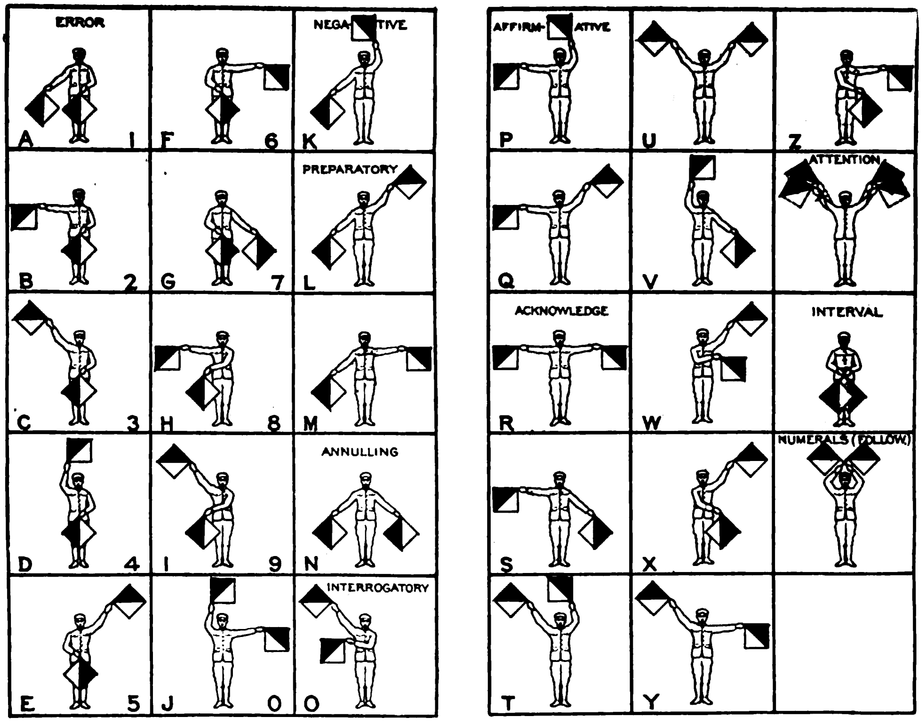
LETTER CODES

INFANTRY

For use with General Service Code or semaphore hand flags.

Letter of alphabet	If signaled from the rear to the firing line	If signaled from the firing line to the rear
A M	Ammunition going forward	Ammunition required
C C C	Charge (mandatory at all times)	Am about to charge if no instructions to the contrary
C F	Cease firing	Cease firing
D T	Double time or "rush"	Double time or "rush"
F	Commence firing	
F B	Fix bayonets	
F L	Artillery fire is causing us losses	
G	Move forward	Preparing to move forward
H H H	Halt	
K	Negative	Negative
L T	Left	Left
O	What is the (R N, etc.)?	What is the (R N, etc.)?
(Ardois and semaphore only)	Interrogatory	Interrogatory
..——.. (All methods but ardois and semaphore.)	What is the (R N, etc.)? Interrogatory	What is the (R N, etc.)? Interrogatory
P	Affirmative	Affirmative
R N	Range	Range
R T	Right	Right
S S S	Support going forward	Support needed
S U F	Suspend firing	Suspend firing
T	Target	Target

Recruit instruction in semaphore signaling by flags



Alphabet of two-arm semaphore with flags

CAVALRY

For use with General Service Code or Semaphore hand flags.

AAA—Ammunition going forward (if signaled from the rear to the front).
—Ammunition required (if signaled from the front).
CCC—Charge (if signaled from the rear to the front).
—About to charge, if no instructions to contrary (if signaled from the front).
CF—Cease firing.
DT—Double time, rush, or hurry.
F—Commence firing.
FL—Artillery fire is causing us losses.
G—Move forward (if signaled from the rear to the front).
—Preparing to move forward (if signaled from the front to the rear).
HHH—Halt.
K—Negative
LT—Left.
M—Bring up the horses (if signaled from front to rear).
—Horses going forward (if signaled from rear to front).
O—What is the (R N, etc.)?
..—— ..What is the (R N, etc.)? Interrogatory (all methods but ardios). and semaphore).
P—Affirmative.
R—Acknowledgement.
RN—Range.
RT—Right.
SSS—Support going forward (if signaled from the rear to the front).
—Support needed (if signaled from the front to the rear).

Signal Corps camp of the Eastern Division, U. S. Army

SUF—Suspend firing.
T—Target.

FIELD ARTILLERY

For use with General Service Code or Semaphore Hand Flags.

........—Error (all methods but ardois and semaphore).
A—Error (ardois and semaphore only).
AD—Additional.
AL—Draw ammunition from limbers.
AKT—Draw ammunition from combat train.
AM—Ammunition going forward.
AMC—At my command.
AP—Aiming point.
B (numerals)—Battery (so many) rounds.
BS (numerals)—(Such.) Battalion station.
BL—Battery from the left.
BR—Battery from the right.
CCC—Charge (mandatory at all times). Am about to charge if not instructed to contrary.
CF—Cease firing.
CS—Close station.
CT—Change target.
D—Down.
DF—Deflection.
DT—Double time. Rush. Hurry.
F—Commence firing.
FCL (numerals)—On 1st piece close by (so much).
FL—Artillery fire is causing us losses.
FOP (numerals)—On 1st piece close by (so much).
G—Move forward. Preparing to move forward.
HHH—Halt. Action suspended.
IX—Execute. Go ahead. Transmit.
JI—Report firing data.
K—Negative. No.
KR—Corrector.
L—Preparatory. Attention.
LCL (numerals)—On 4th piece close by (so much).

LOP (numerals)—On 4th piece open by (so much).
LT—Left.
LL—Left from the left.
LR—Left from the right.
LE (numerals)—Less (so much).
MD—Move down.
ML—Move to your left.
MR—Move to your right.
MU—Move up.
MO (numerals)—Move (so much).
N—Annul, cancel.
O— What is the (R N, etc.)? Interrogatory. (Ardois and semaphore only.)
..——..— What is the (R N, etc.)? Interrogatory. All methods but ardois and semaphore.)
P—Affirmative. Yes.
PS— Percussion. Shrapnel.
QRO—Send faster.
QRS—Send slower.
QRT—Cease sending.
R—Acknowledgement. Received.
RS—Regimental station.
RL—Right from the left.
RR—Right from the right.
RN—Range.
RT—Right.
S—Subtract.
SCL (numerals)—On 2d piece close by (so much).
SOP (numerals)—On 2d piece open by (so much).
SH—Shell.
SI—Site.
SSS—Support needed.
T—Target.
TCL (numerals)—On 3d piece close by (so much).
TOP (numerals)—On 3d piece open by (so much).
U—Up.
Y (letter)—Such batterv station.

The selection of the site for a visual signal station is governed by choice of a point perfectly in view of the communicating station, the exact position in which the flagman is to stand being arranged, if possible, so that he will have behind him for every signal a background of the same color.

Secrecy in communication is vitally important. Even though the code used may not be known to the enemy, the waving flag or other means of visual signaling will inform the enemy that he has probably been observed; stations should therefore be located where they will be most difficult of discovery. If there is reason to believe that signals are seen by the enemy, they should be made in cipher and extraordinary care be taken in transmitting messages. Where practicable, they should be repeated.

The distant station is the best judge of background, and it should indicate the color of flag wanted.

The following table shows how far an object at sea level can be seen:

Height of the eye above sea level (in feet)	Distance (in statute miles)
10	4
15	5
20	6
30	7
40	8
50	9
60	10
70	11
85	12
100	13
115	14
130	15
150	16
200	18
230	20
300	23
350	25
500	30
700	35
900	40

Hence, an observer whose eye is 30 feet above the sea can distinguish an object 7 miles distant, providing it is at the sea level; but if the object itself is 15 feet above the sea he can make it out $7 + 5 = 12$ miles off.

In visual signaling over a distance the telescope is used. In locating the signalman at any known station, some prominent landmark is noted with the unaided eye and the telescope then directed upon the place and the country near the marker scaled until the signalman is found. When the compass bearing is known the telescope is aligned with the proper compass bearing and the telescope moved slowly from side to side until the whole country in that direction has been scrutinized.

The magnetic bearing of all communicating visual stations is always carefully noted. In addition, guide lines may be established by driving two stakes firmly into the ground and close to each other. A line through the center of these should point the direction of the distant station. If more than one station is being communicated with, the various names should be written under the lines which mark each one.

A signal officer should provide himself and those working under him with the latest and most accurate topographic maps of the country. The location and call letters of all stations and the personal signals of his subordinates should be recorded and made known to all under his jurisdiction.

The called station should respond at once when its particular signal is shown.

A continuous watch for signals should be kept and assignments recorded so that responsibility for neglect to promptly answer calls may be determined.

When a station has sent all messages on hand, the signal "Cease signaling" should invariably be made. When nothing more is to be sent from either station, both make "Cease signaling."

If a signal station asks another to move its station to the right or left, both stations appoint a signalman to hold a flag above his head. The station asking for the change lowers its flag immediately when the proper background is found.

Attempts to attract the attention of a station must be persistent. They should never be abandoned until every device has been exhausted, and should be renewed and continued at different hours.

How to Become an Aviator

The Third Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Airplane Design, Power, Equipment and Military Tactics

By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

INDICATIVE of the giant strides made in the development of aeroplanes is the announcement that the United States is considering the delivery of its vast air fleet to the European battlefields by direct flight, instead of ship transportation. Equipped with engines which can maintain a speed of eighty miles an hour, and built to carry several tons of fuel, the new aircraft through which we hope to strike the crushing blow to Germany can well be conceived making the cross-ocean flight in safety within twenty-four hours.

The air dream of yesterday is today's reality.

Navigation has been up to now considered one of the greatest obstacles to trans-Atlantic flight, the danger of the pilot losing his way, say, between Newfoundland and the Azores, having long been of serious concern to those who have plotted ocean routes. In wireless will the solution be found, however. The direction finder, or radio goniometer, a familiar instrument to readers of THE WIRELESS AGE, is to be the basis of the new air navigation instruments, according to present plans. With this instrument pointing the way to a sending station in the Azores, or similar objective point, the danger of the aviator losing his way will be reduced to the minimum. More and more each day, aviation and wireless, the two arts giving mastery of the air, are becoming more closely allied.

Better than any letter of introduction is knowledge of wireless for readers of THE WIRELESS AGE who have in mind enlistment in the aviation sections of our military establishment. Since a large proportion of our aviators must be radio operators, qualification for wartime service in our flying section is thus made easier, for less instruction of the pupil is required.

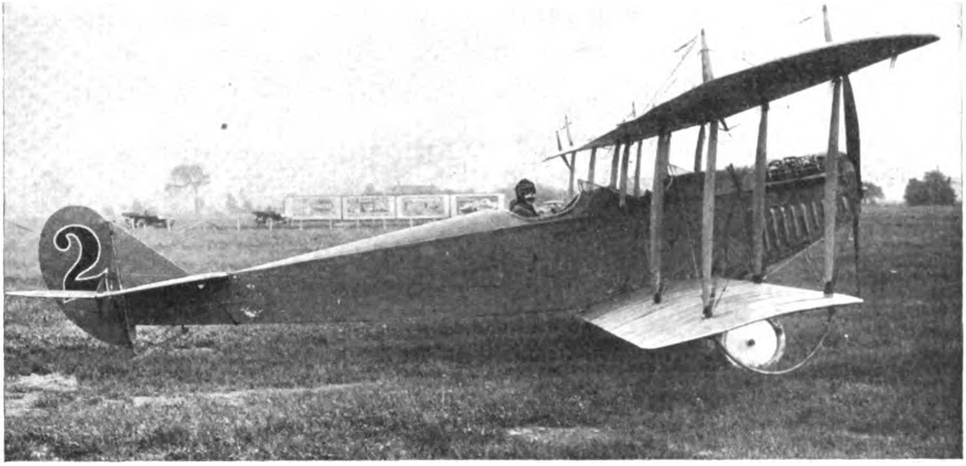
But, as in the study of radio communication, the prospective aviator must be thoroughly grounded in the fundamentals. Both safety and common sense demand that the aviator know more of hismac hine than the mere manipulation of the conerols.

It is this study of fundamentals which will now be taken up in the series.

Military aeroplanes will of course be given first consideration. Some aeronautical generalities are necessary, however, in dealing with design and construction, but these will be treated briefly.

The aeroplane is but one form of flying machine. Leaving balloons of various types entirely outside the question, there still remain three types of heavier-than-air machines. We will devote all our study to the aeroplane, but passing reference should be made to the other two types before proceeding. These are:

The Helicopter—a machine which employs the principle of direct lift by means of an air screw propeller operating on a vertical axis. This is not a practical type of flying machine and little has been done with it.



An aeroplane of the "tractor" type, so called because the propeller is attached to the front, pulling the machine through the air

The Ornithopter—a machine which derives its name from the bird, its principle being the creation of flapping wings given a reciprocal motion somewhat similar to rowing, the forward push intended to exactly counterfeit that of the bird's wings. These machines are not yet successful.

The reader may be fascinated by the possibilities of research into the field represented by this latter type, but considering the present efficiency of the aeroplane, it is safe to assume that time will be better spent in utilizing its man-discovered principles of flight, rather than in following a new line of thought on the assumption that Nature never makes a mistake and the bird is therefore the best model.

It must be remembered that flying is but an incident in the life of a bird, just as walking is to a man. The famous aviator Santos-Dumont drew a parallel which disclosed the folly of blindly following Nature, when he pointed out that such a procedure would have resulted in locomotives being built with huge iron legs and steamships with the flapping fins and lashing tail of the whale. Sir Hiram Maxim further blasted the bird-flight theory by noting that "in order to build a flying machine with flapping wings, to exactly imitate birds, a very complicated system of levers, cams, cranks, etc., would have to be employed, and these of themselves would weigh more than the wings would lift."

Without further comment, therefore, we will confine ourselves to the aeroplane, the most successful type of aircraft and the best developed means of navigating the air.

The aeroplane is sustained by the upward push of the air flowing past it; it therefore is composed of (a) lifting surfaces, (b) power for propulsion.

Propulsion through the air is effected by a propeller, identical in principle though not in appearance, to the screw on a boat. An engine drives this propeller at the required velocity. The propulsion produced by the propeller is called the *thrust*.

When the propeller is attached to the front, pulling the machine through the air, the aeroplane is called a *tractor*.

If the propeller is back of the wings, or main lifting surfaces, the aeroplane is called a *pusher*.

The tractor type, with a single propeller, is generally acknowledged the most efficient all-around machine, although pushers with two air screws have distinct values in gun-carrying machines.

An aeroplane with two wings, one above the other, is known as a *biplane*.

The single wing type, with but one lifting surface, is called a *monoplane*.

The *tractor biplane* is the type which is more nearly standardized and will be principally considered here.

The main lifting surfaces are planes, or "wings," which present their widest dimension across the line of flight and create the air compression on their surfaces which produces flight.

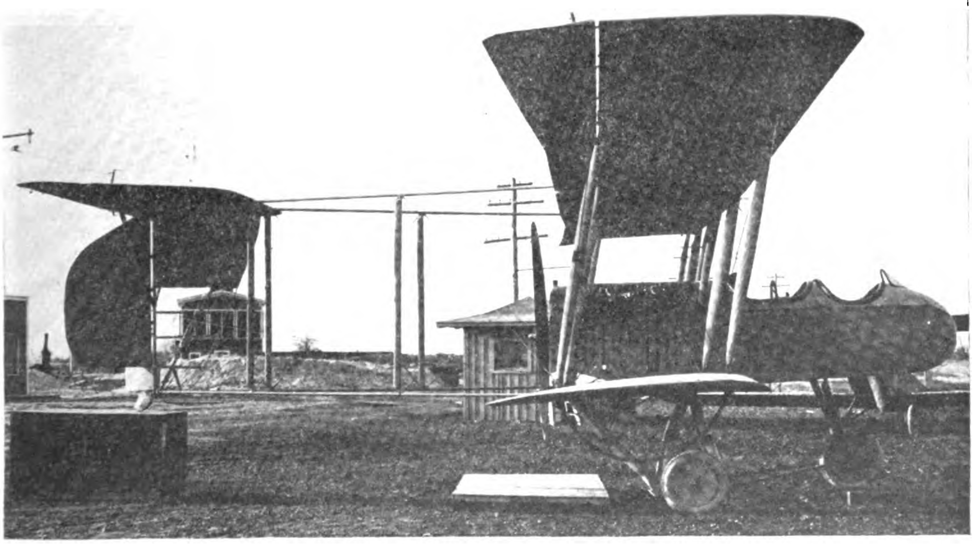
The body to which these planes are attached is known as the *fuselage*, the engine and seats mounted in it being enclosed to lessen the resistance of the wind.

Since the aeroplane "sails" through the free air, it has three axes of rotation.

(1) It may ascend or descend. This is known as pitching, and is controlled by depressing or elevating an *elevator* by means of suitable controls.

(2) It may change its direction of travel, or steer to right and left. This is called *yawing*, and is made possible by the operation of a rudder.

(3) It may tip over to either side, a movement termed *banking* or *rolling*. This lateral motion is offset by three means of control which give a difference in angle to the two sides of the wing surface, causing one side to lift more than the other. The controls are: (a) *ailerons*, small planes set at each side, between and independent of the main lifting surfaces; (b) *wing flaps*, which are hinged portions of the main planes; (c) *warping*, or twisting the main lifting surfaces to simultaneously lessen and increase the angle of inclination to the wind as required on both sides.



A "pusher" biplane with the propeller back of the wings or main lifting surfaces

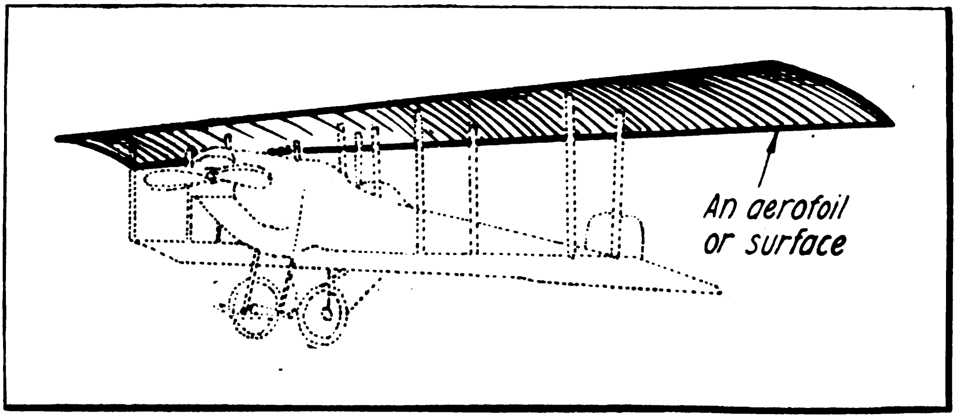


Figure 1—*A lifting surface*

THE PRINCIPLE OF FLIGHT

The upward air pressure against its main wing surfaces enables the aeroplane to fly, when these wing surfaces, or planes, are set at an angle inclined from the direction of motion, the pressure being supplied by the speed at which the planes are driven by the propeller.

AIR--Air is attracted by the mass of earth, or the gravity force, and therefore has **weight.** A cubic foot of dry air, at sea level and 32 degrees Fahrenheit temperature, weighs 0.0807 lb. Its density decreases with altitude, until at a mile above sea level it weighs 0.0619 lb., and at five miles, 0.0309 lb. per cubic foot.

Air also has **motion,** which must be taken into consideration by the aviator, and **resistance,** due to density and intensity of motion, or wind. Air resistance comprises:

Inertia—Its tendency to remain at rest, if still; in motion, if moving.

Elasticity—Its tendency to reoccupy its normal amount of space after being disturbed.

Viscosity—The tendency of particles of air to resist separation.

Inertia gives the propeller its "hold" in the air; elasticity, when air is compressed under the surface of the plane, aids the lift; viscosity creates fricton, which is minimized by using polished surfaces and stream-lining aeroplane parts.

THE SURFACE

A wing surface is meant by this expression (see Figure 1). It has a strictly aeronautical designation, viz.:

THE AEROFOIL

This term is seldom used bv aviators, but is commonly employed by aeronautical engineers to differentiate between an ordinary surface and one inclined at an angle to the direction of motion, having thickness, and curved to secure a reaction from the air for lifting.

CAMBER

This is the term which designates the curvature of the surface, or aerofoil.

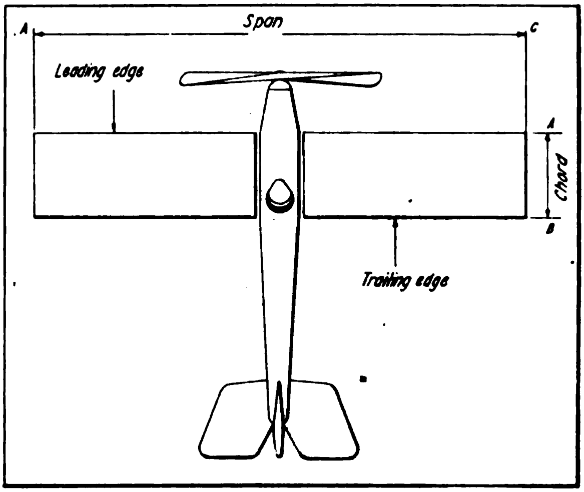


Figure 2—The chord and span of a wing surface

THE CHORD

This is the dimension of an imaginary straight line from the front edge of the aerofoil, or surface, to the rear edge, as shown by A—B, in figure 2.

The front edge of the wing is known as the **leading edge,** and the rear as the **trailing edge.**

SPAN

This is the dimension of the surface across the direction of motion, indi-cated by A—C, in figure 2.

THE ANGLE OF INCIDENCE

This is the angle of inclination of the chord to the air stream.

In practice this is the angle of inclination of the chord to the line of the propeller thrust. If the leading edge of a surface is above the trailing edge when driven through the air, the angle of incidence is **positive.** A surface with the trailing edge presented above the leading edge, or negatively to the air flow, would bring the air pressure to the top of the surface and constitute a **negative** angle.

LIFT BY AIR PRESSURE AND SUCTION

Having considered the aeroplane wing as a surface, its action upon the air will be described.

Air, or the atmosphere, has characteristics similar to water, the atmosphere being an ocean of definite extent and pressure at different altitudes, and flowing past an object either in stream lines, or in broken up eddies due to disturbances in its flow.

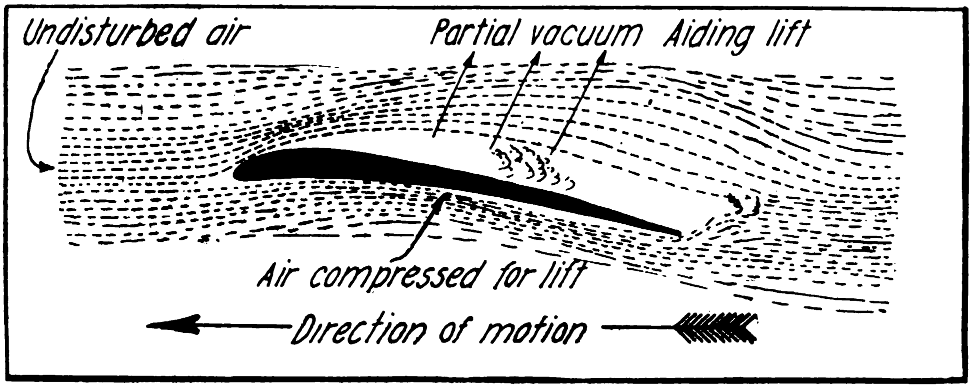


Figure 3—Action of air on the aerofoil

The nature of the air pressure when encountering the aerofoil is shown in the drawing, figure 3.

The under face of the aeroplane wing compresses the air, resulting in a positive force.

At the same time a suction is caused by the air flowing past the upper face, causing a partial vacuum, tending to draw the surface upward.

The value of this suction is about three-quarters of the total pounds force of the air's action on the aerofoil. The factors of this air reaction are:

(a) The mass of the air.

(b) The velocity of the aerofoil.

The reaction increase is as the square of the velocity.

The air reaction has two values:

LIFT—opposed to gravity, or the aeroplane's weight.

DRIFT—opposed to the thrust of the propeller.

The lift is opposed by the drift, which must be overcome by the thrust supplying velocity great enough to produce air reaction sufficient to produce **flight.**

Drift is of three kinds: (a) **active drift,** produced by the velocity of the lifting surfaces; (b) passive drift, the resistance of other parts of the aeroplane, such as struts, wires, tank, fuselage, hood, etc.; (c) **skin friction,** or the air resistance on roughness of surface.

LIFT AND DRIFT

It has been shown how the air pressure is created on a surface inclined at a positive angle to the direction of motion, and that this pressure exerts a lifting force.

The air pressure is inclined upward and to the rear of the direction of motion in a ratio equal to the variance of the angle of incidence of the wing plane.

The vertical action of the air pressure is a force capable of lifting weight but its horizontal component of air pressure represents resistance to motion.

Thus, while

LIFT is a vertical air pressure.

DRIFT, its horizontal component, is resistance.

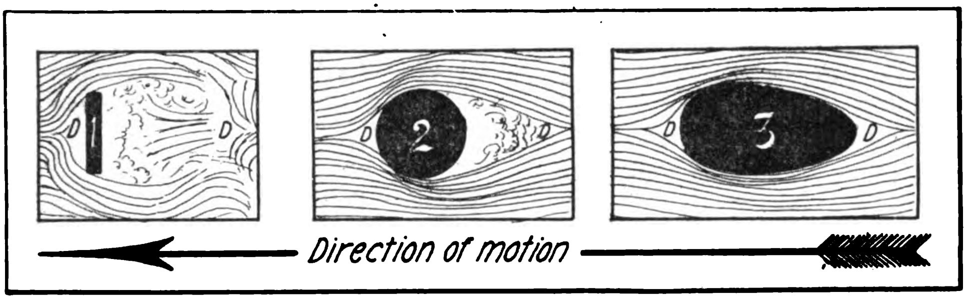


Figure 4 *Figure* 5 *Figure* 6

LIFT-DRIFT RATIO

Flight is maintained by the proportion of lift to drift being sufficiently great to overcome the force of drift, the characteristics of the wing surface being designed for the greatest lift with the smallest consequent drift, so that minimum power supplies maximum capacity for load carrying.

The factors to be considered in determining lift-drift ratio are **velocity, angle of incidence, camber** and **aspect ratio.**

VELOCITY

Drift increases to lift proportionately with increase of velocity.

Active drift, formed by the wing surfaces, is a component part of the air reaction which creates the lift, and therefore increases as the square of the velocity. At all speeds the efficiency of the aeroplane would remain the same, but for the

Passive drift, or the resistance of the aeroplane parts other than the lifting surfaces, which also increases as the square of the velocity, yet adds nothing to the lift. Thus by adding its resistance to the active lift, it prevents the aeroplane's ratio of lift to drift from increasing proportionately with the increase of the thrust. In other words, the efficiency of the aeroplane would not decrease with added velocity, if it were not for the passive drift. This factor prevents, so to speak, doubling the speed or lift by doubling the thrust.

To diminish the passive drift all parts of the aeroplane are given **stream lines,** or a form offering least resistance as they pass through the air.

Head resistance is a term formerly employed to describe passive drift. It has been largely discarded, however, for its inaccuracy of description of the effect of the action of parts in air reaction. Passive drift is due more to the action on the rarefied area behind the object than to the head or forward part of hood, struts, wires, etc.

FLOW OF AIR

Figures 4, 5, 6 illustrate the flow of air around three objects of varying form.

In figure 4 the rarefied area, or drift, is represented by D—D, and is of marked extent.

In figure 5, this area, indicated by the same symbols, has decreased, the air flowing closer to the spherical body.

Figure 6 shows the rarefied area still further diminised, the shape of the body being conducive to closer air flow.

These three figures illustrate the importance of stream-lining parts on the line of flight.

As the head resistance is increased by the rarefied area in the rear of the object, the thrust required increases proportionately.

The action of air on objects of different shapes and propelled at varying velocities is determined by visualizing the air in laboratory research with wind tunnels.

ANGLE OF INCIDENCE

This is the angle of inclination of the chord to the air stream. Its efficiency varies and is determined by what is desired in thrust, weight-carrying capacity, and ratio of climb to velocity.

It may be accepted as a general premise that the greater the velocity the smaller should be the angle of incidence, so that the rarefied area may be kept to stream-lines and the eddies of air reduced to a minimum. These eddies represent drift, since they have no lift, and when produced by too great an angle of incidence, the power required to produce them is wasted, with consequent loss in efficiency of the aeroplane.

Wind tunnel research largely determines the best angles of incidence.

CAMBER

The purpose of the camber, or curve, in a lifting surface is to decrease the active drift, horizontal component of the lift.

Camber of lower face—The horizontal air reaction from a flat surface would be considerable and increase the drift. Curving the wing surface compresses and accelerates the air from the leading edge to the trailing edge. If this air action is not uniform the drift will be increased.

With a fixed upper face, an increase in the camber of the lower face does not greatly vary the relation of lift to drift, but lift increases with camber increase. Most of the lift is furnished by the upper face, however, and the camber increase of the lower does not produce sufficient effect on the upper to compensate for the lessened depth of spar allowed when a rather flat surface is used. Increased depth of spar permits a weight reduction in the framework of the wing without sacrifice of strength. It is for this reason that lessened camber for the under side is allowed.

Camber of upper face—The top surface is curved to produce the least possible eddies of air resistance behind the trailing edges, the rarefied area produced being given the best obtainable stream line to lessen the drift in the lift-drift ratio.

Velocity, angle of incidence and thickness of aerofoil, or surface, determines the camber of the upper face. In general, the camber and angle of incidence should decrease proportionately with velocity increase.

On an aerofoil with a *flat* under face the maximum lift increases with the upper face cambered up to 1/15, beyond which it decreases. Improvement of the lift-drift ratio is steady up to 1/20 camber, thereafter showing decrease in value with deeper cambers.

With the under face *cambered* the increase of upper face camber above 1/15 shows little variation in lift, but steady increase of drift.

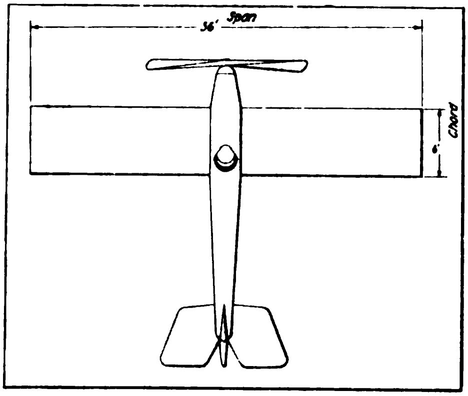


Figure 7—High aspect ratio

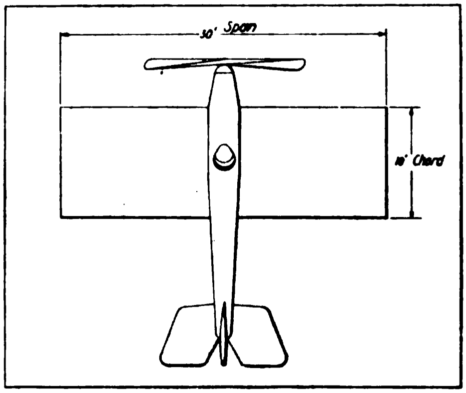


Figure 8—Low aspect ratio

ASPECT RATIO

The proportion of span to chord is the aspect ratio. The total span divided by the chord of the wings is the "aspect" of aeroplane.

In figure 7 the span is 36 feet, the chord is 6 feet, the aspect ratio is therefore 6 to 1.

At a given velocity and given wing area, the reaction increases with increase in aspect ratio. The reason for this is that a greater mass of air is engaged with a wider span, the reaction of air being partly the result of the mass of air engaged.

An average aspect for an aeroplane is 6, but in deep cambered planes an aspect of 9 is considered practicable by designers.

In a general way it may be said that the higher the aspect ratio, the better is the lift-drift ratio. But with decrease of chord the deepening of the camber requires added thickness of aerofoil, or surface, and in practice the reduction of chord required for an extremely high aspect ratio makes prohibitive the use of the thickness of surface which would give the best camber.

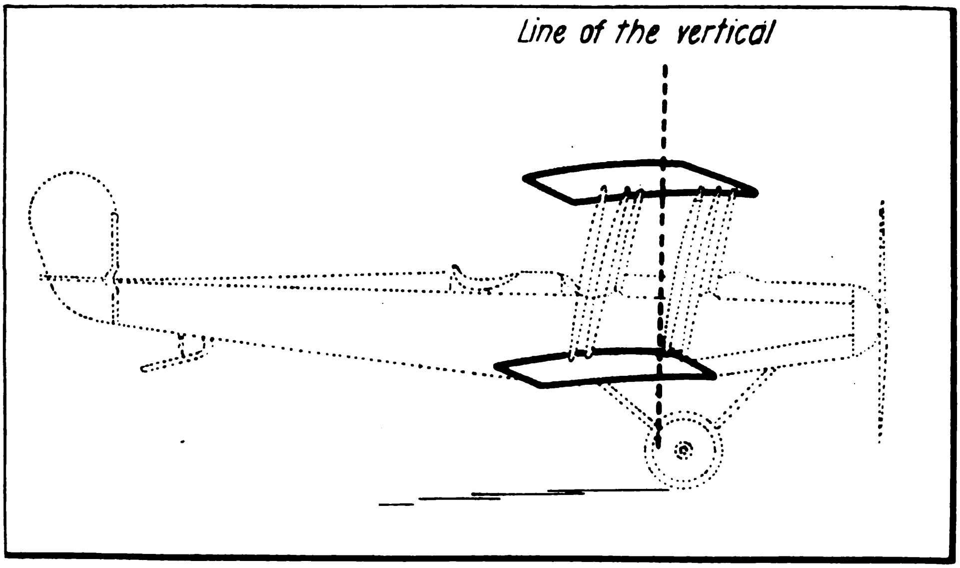


Figure 9—The upper plane placed in advance of the lower, or staggered

STAGGER

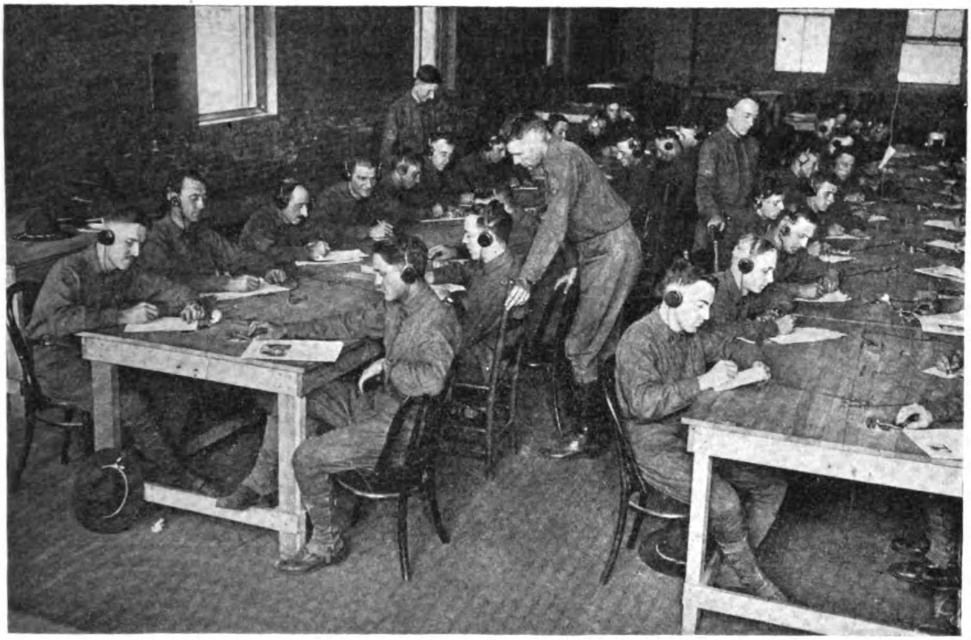
When the top surface of a biplane is placed in advance of the vertical with relation to the lower wing surface, the term stagger is used.

See Figure 9.

By staggering the upper plane ahead of the lower plane it is removed from the area of action of the lower aerofoil and engages undisturbed air.

Without stagger, the confusion of air reaction could be obviated by increasing the gap between upper and lower planes a dimension equal to 1½ times the chord. But the length of struts and wires required for this opening increases the drift, making it impracticable to have a gap much greater than the chord.

Minor considerations of construction and balance, and visibility for pilot and observer, govern the proportion of stagger, although, theoretically, the upper plane should be advanced a distance about equal to 30 per cent. of the chord, small variations being further governed by velocity and angle of incidence.



The telegraph room, showing members of the Signal Corps at practice

Training Signal Corps Men at Pratt Institute

Drill, Military Discipline and War Wireless Instruction in Halls of Learning

THE customary silence which prevails in the spacious halls and grounds of Pratt Institute, Brooklyn, N. Y., gave way during the past Summer to the martial tread of many feet; staccato commands sent alert khaki-clothed figures hurrying here and there; a military air pervaded every nook and corner; in a word, the Institute was turned into training quarters for a detachment of Depot Co. H, United States Signal Reserve Corps.

Among those preparing themselves to serve their country were representatives of many walks in life. One man left an important post with a widely-known banking firm to join the Corps; another came from among the tried men in a great industrial corporation; here and there were amateur wireless men learning to put to practical use the knowledge which they acquired during their spare hours. Commercial wireless men and students from technical schools were also found in the detachment.

The detachment was organized by First Lieutenant John A. Zimmerman, First Lieutenant Grover Pipkin of the United States Army being placed in command. It was divided into two sections which alternated in the following daily program:

The men were awakened at six o'clock in the morning, roll call taking place ten minutes afterward, after which came a run of about a quarter of a

mile and setting-up exercises. Mess time was set for half-past seven o'clock, two hours of drill following. The electrical class met at half-past eleven o'clock and at twenty-five minutes to twelve o'clock the men sat down at the mess table. From fifteen minutes after one o'clock till fifteen minutes after two, conversational French lessons were given. This instruction was provided through the Y. M. C. A. At half-past two o'clock the section returned to the telegraph room, remaining there for an hour, when it took up work in the laboratory. At half-past four o'clock telegraph practice was taken up. This lasted an hour and at six o'clock the men again sat down at the mess table.

In the telegraph room a service buzzer and the regulation pack set were used, the buzzer current being obtained by induction. Instructions in receiving

There is considerable diversity in the training. This is a photograph of the men receiving instruction in the laboratory

were given in the morning and transmitting was taught in the afternoon. The room was in charge of a master signal electrician, the instructors being alternated in order to obtain a diversity of method teaching. Examinations were held once a week to determine the progress made by each member of the classes.

Considerable attention was paid to assembling and tearing apart the pack set, which is of the regulation ¼ K. W. type.

The training quarters were recently moved to the College of the City of New York, New York, where the work begun at Pratt Institute is being continued.

The activities of the Signal Corps men told of in this article are part of the plan of Brigadier-General George O. Squier, chief signal officer, United States Army, to use educational institutions throughout the country as training camps. How well the plan is succeeding is attested by the fact that many of the men in the detachment of Depot Co. H who were unfamiliar with wireless telegraphy before July 2d, when their training began, are now able to copy wireless messages at excellent speed.

Wireless Instruction for Military Training

A Practical Course for Radio Operators

ARTICLE VI

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE.—This is the sixth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

THE DYNAMO AND THE MOTOR

THE DYNAMO

(1) We have shown how a coil of wire placed in a magnetic field of varying strength will have an electric current induced in it, and it is immaterial whether the field is of varying strength and the coil is stationary or the field is of constant strength and the coil is moved through it. So long as there is relative motion between the coil and the field, an E. M. F. will be generated in the coil, the magnitude of which will be proportional to the rate of change of flux.

(2) We have already remarked that the machine built on the principle of revolving a coil or a number of coils of wire through a magnetic field, for the production of electromotive force, is called a dynamo or generator; and a dynamo may generate direct or alternating current. An alternating current dynamo is frequently called an alternator.

(3) We may define the **dynamo** as a machine for the conversion of mechanical energy to electrical energy.

(4) A dynamo consists in the main of a powerful set of **electromagnets,** an armature, collector rings or commutator, and brushes for conducting the electric current away from the armature coils.

(5) The coils of the armature are generally wound in slots on an iron core, and as the armature revolves (driven by an external mechanical source of power) they are filled and emptied with magnetic lines of force. At the moment that a given coil is completely emptied of lines of force, the maximum induction takes place, i. e., the current induced in the armature coil reaches its maximum.

(6) Stated in another way, when a conductor revolves through a magnetic field, the current induced therein will attain its greatest amplitude when the conductor moves at right angles to the field.

(7) When a dynamo is constructed to generate alternating current, the current is collected from the armature by brushes making contact with two brass rings which are mounted on the same shaft with the core, but if it is designed to generate direct current, a device known as a **commutator** is mounted on the shaft of the armature. The function of the commutator is to change alternating current to direct current.

(8) Dynamos are designed to have special operating characteristics according to the nature of the service in which they are employed. Direct current dynamos may have **series, shunt** or **compound** field windings. (To be explained further on.)

THE ELECTRIC MOTOR

(1) The armature of any direct current dynamo if fed with electricity from an outside source will revolve as a motor. The motor may be defined as a machine to convert electrical power into mechanical power.

(2) There is essentially no difference in the construction of a D. C. motor and a D. C. generator.

(3) Motors, as we have previously declared, are employed principally in wireless telegraphy to drive alternating current generators, and when the two units are coupled on the same shaft, the complete machine is called a **motor generator.** A motor generator therefore makes available an alternating current from a direct current source of supply, or vice versa. Occasionally, an **alternating current motor** is employed to drive an alternating current generator simply to change the frequency of the current supply. Such machines are called frequency changers.

(4) Motors may have **series, shunt** or **compound** windings according to the service in which they are employed.

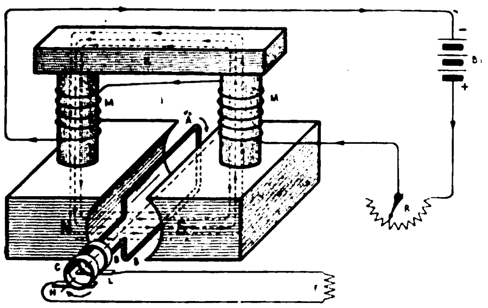


Figure 30

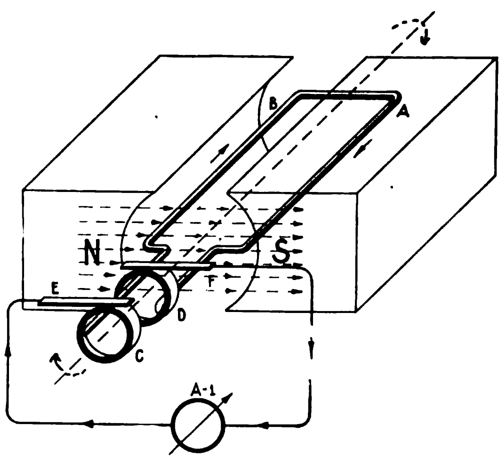


Figure 31

OBJECT OF THE DIAGRAMS

To show the fundamental working principle of the alternating current dynamo or alternator.

PRINCIPLE

A copper conductor (or a series of conductors) if rotated through a magnetic field will have an E. M. F. generated in it, and if the conductor forms a closed circuit, a current of electricity will flow.

This current will reverse its direction periodically, the number of reversals increasing as the number of north and south poles, or as the speed at which the coil rotates.

DESCRIPTION OF THE APPARATUS

In Figure 30, an electromagnet, K, with poles N and S has the windings, M, M, which are connected to a source of direct current, either a battery or storage cells or a small direct current dynamo.

A rectangle or a coil of wire, A, B, is assumed to be mounted on a shaft supported on bearings so that it can revolve clockwise through the field created by the N and S poles. The rectangle is in the neutral magnetic field.

The terminals of the armature coil, A, B, are connected to two copper or brass rings mounted on a driving shaft, but insulated from it. Two copper or carbon brushes make contact with the rings, and the external circuit, therefrom, is completed through the load, F.

In Figure 31, the rotating coil is shown in the position of maximum induction, that is to say, the A side of the rectangle is under the S pole, and the B side under the N pole. Current now flows in the external circuit in the direction shown by the arrows.

OPERATION

The coil, A, B, may be driven by a steam engine, gas engine or by an electrical motor whereupon an alternating current will be induced in the coil, which will continually reverse through the external circuit. The number of reversals per second will vary as the speed of rotation.

SPECIAL REMARKS

(1) If the coil, A, B, cuts through 100,000,000 lines of force per second, an E. M. F. of one volt will be generated.

(2) The armatures of commercial alternating current **generators** or **alternators,** as they are sometimes called, are composed of several loops of wire instead of the single loop shown in Figures 30 and 31.

(3) These loops or coils are mounted in slots on an iron core, the core revolving **between the field poles, N. S.**

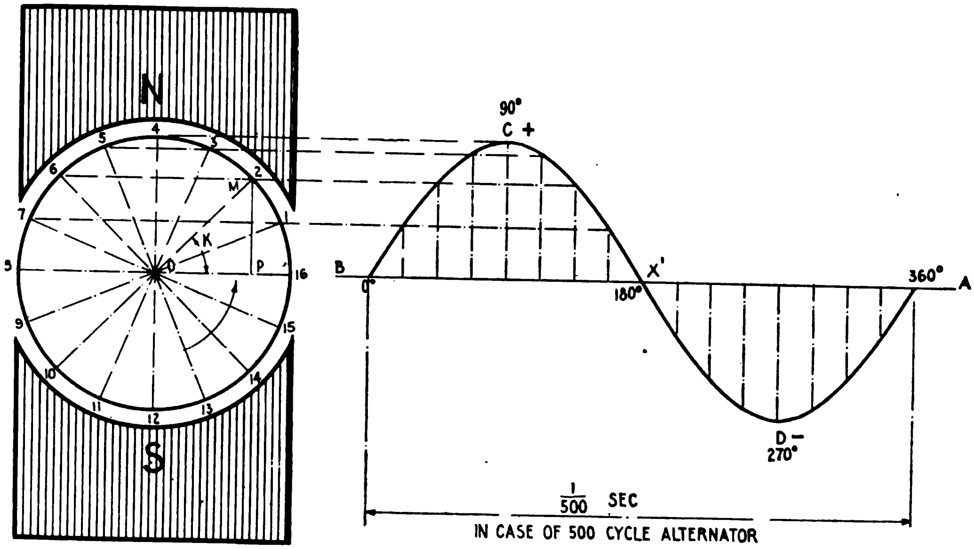


Figure 32

OBJECT OF THE DIAGRAM

To show graphically the rise, fall and reversal of an alternating current in a dynamo armature.

PRINCIPLE

The amplitude of the current generated in a dynamo armature is proportional to the sine of the angle of revolution.

DESCRIPTION OF THE DRAWING

The circle within the field poles, N and S, with the consecutive numbers 1, 2, 3, 4, 5, etc., is assumed to represent a dynamo armature having several coils mounted thereon as in modern commercial machines.

The horizontal axis, B, X′ A, is divided into fractions of a second, and the vertical axis (not shown) is scaled to represent the amplitude of the current at successive positions of the armature coil during a complete revolution.

Assuming that the armature rotates clockwise, then the position in which the rectangle, A, B, of Figures 30 and 31 will receive the minimum induction is that of the line, 16-8, and as shown by the horizontal axis, B, X′ A, the current is zero. The amplitude of the current increases gradually as the side of the rectangle takes the successive positions, 1, 2, 3, 4, the maximum cutting taking place in the position, 4-12. This corresponds to point C on the curve and represents the maximum amplitude of the positive alternation.

As the armature coil continues to revolve, taking up the positions 4, 5, 6, 7, 8, the current gradually reduces to zero, that is, in the position, 8-16. As the armature continues the revolution, a second increase in current takes place, but in the opposite direction to that of the previous maximum position, maximum induction taking place in the coil when it attains the position, 12-4, and as the coil continues to revolve, the current drops to zero when the coil is in the position, 16-8.

In the ideal case, the current thus rises and falls uniformly and the current continually reverses its direction.

SPECIAL REMARKS

(1) Not all commercial alternating current generators possess the genuine sine wave form. The maxima of the curves may be decidedly "peaky" or be more or less flat, depending upon the design of the machine.

QUES.—How are the number of reversals of current per second designated in alternating current circuits?

Ans.—By the term frequency.

QUES.—How is the frequency of an alternating current generator determined?

Ans.—In multiplying the number of field poles by the speed of the dynamo armature per second and dividing the result by two. The frequency can also be measured directly by a frequency meter.

QUES.—What effect has an increase of speed of an alternating current dynamo upon the frequency?

Ans.—The frequency will increase directly with the speed.

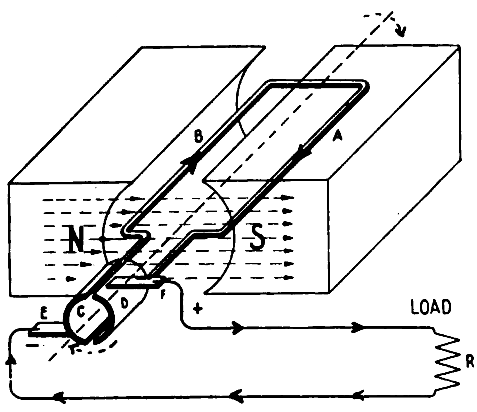


Figure 33

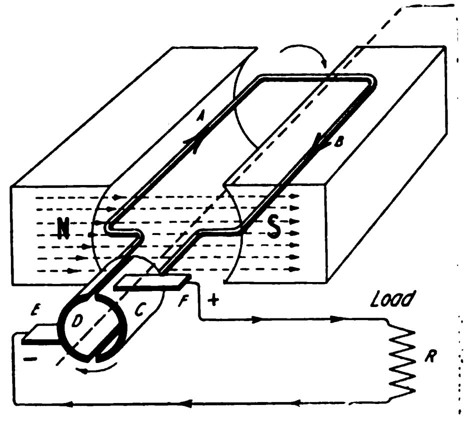


Figure 34

OBJECT OF THE DIAGRAMS

(1) Figure 33—To show how direct current can be obtained from a dynamo.
(2) Figure 34—To show the function of a simple commutator.

PRINCIPLE

By placing an appropriate device known as a commutator on the end of an alternating current dynamo armature shaft, the alternating current can be converted into a direct or uni-directional flow of current.

DESCRIPTION OF THE APPARATUS

An armature coil A, B, with the commutator, C, D, is assumed to be mounted on a shaft and to rotate in a magnetic field, as in the previous diagrams.

The commutator, C, D, revolves with the coil, A, B, and in reality consists of a split brass or copper ring mounted on the shaft and insulated from it. Brushes F and E make contact with the commutator.

In Figure 34, the coil, A, B, is shown in just the opposite position to that of figure 33.

OPERATION

If the coil, A ,B, rotates clockwise, then in the position shown in Figure 33 the current will flow towards the front in A and towards the rear in B. The brush, F, makes contact with the commutator segment, D, and the current induced during the revolution of the coil flows in the external circuit in the direction of the arrows.

As shown in Figure 34, when A, B, attains just the opposite position to that shown in Figure 33, the current flows toward the front in side B and towards the rear in side A, but commutator segment C now makes connection with brush F and brush F is therefore positive as before. Current will now flow in the same direction as previously.

SPECIAL REMARKS

(1) Commutators of commercial generators have a great number of segments which are insulated from each other by fibre blocks. The segments of the commutator, are of course, thoroughly insulated from the shaft of the dynamo.

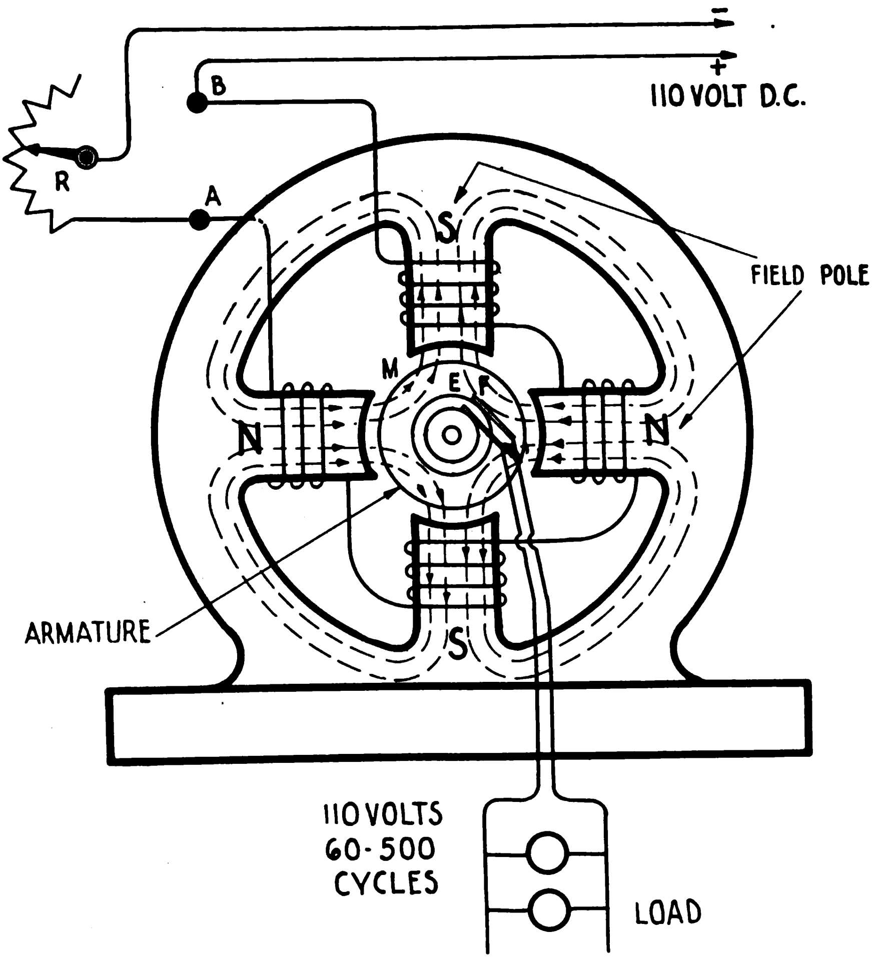


Figure 35

OBJECT OF THE DIAGRAM

To indicate the fundamental electrical and magnetic circuits of a multi-polar alternating current generator.

DESCRIPTION OF THE APPARATUS

An iron frame has the magnetic poles, N, S, N, S, which are wound alternately in opposite directions, the final terminals, A, B, being connected to a direct current source of electricity. A regulating rheostat, R, is connected in series with the field coils to control the flow of the field current The armature is indicated at M, and it is assumed to consist of a soft iron core upon which are mounted copper conductors.

OPERATION OF THE APPARATUS

When the armature, M, revolves at a uniform rate, an alternating current is induced in its coils, which is collected by the brushes, E, F, in contact with two collector rings mounted on the end of the shaft.

The armature, M, is assumed to be driven by an external source of mechanical power, either by belting or by direct coupling.

The voltage developed at the terminals of the armature varies as:

(1) The strength of the magnetic field;
(2) The speed of the armature M.

If, for instance, the armature revolves 1,800 R. P. M., and the E. M. F. is 110 volts, and the speed of the armature is then doubled, the E. M. F. will increase to 220 volts. The voltage can likewise be increased by running the armature at a constant speed, increasing or decreasing the strength of the field current at the rheostat, R. A practical limit would be encountered in such regulation because, as previously mentioned, there is a limit to the number of lines of force which can be stored up in an iron core.

SPECIAL REMARKS

(1) If the armature of Figure 35 revolves at a speed of 1,800 R. P. M., corresponding to thirty revolutions per second, there would be 4 x 30 or 120 reversals of current per second; and since **two alternations of current constitute one cycle, the** frequency of the current would be said to be 60 cycles per second.

DIRECT CURRENT DYNAMOS

(1) We have seen from previous discussions that an alternating current generator requires a source of direct current for excitation of its fields. Generally a small direct current dynamo known as an exciter is employed for this purpose.

(2) It is possible, although it is not often done, to place a **commutator** on one end of an alternating current armature shaft and thus commutate or rectify a portion of the alternating current into direct current. The terminals of the field winding are then tapped across the brushes resting on the commutator, the rectified current flowing to the field windings.

(3) The direct current dynamo or generator, once in rotation, can supply its own field current. It is then known as a **self-excited generator,** and if the terminals of the field windings are shunted across the armature brushes, it is termed a **shunt-wound self-excited generator.**

(4) The field coils of the dynamo may be conected in **shunt** or in **series** with the armature, or for special purposes a dynamo may have **both shunt and series** field windings. In this case the machine is called a **compound wound dynamo.**
(Note: The following diagrams will illustrate 3 and 4.)

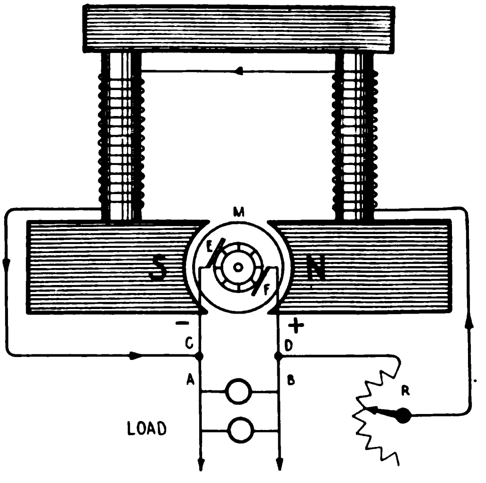


Figure 36

OBJECT OF THE DIAGRAM

To indicate in a general way the circuits of a two-pole shunt-wound direct current dnyamo.

PRINCIPLE

A portion of the current generated in a D. C. dynamo armature may flow to its field windings for purposes of excitation.

By careful regulation of the strength of the field current, the E. M. F. generated by the armature can be closely regulated.

DESCRIPTION OF THE DRAWING

A two-pole self-excited dynamo has the fieldpoles, N and S, the armature, M, and the commutator on which rest the brushes, E and F.

A variable resistance coil, R, called a **field rheostat,** is connected in series with the circuit from the armature to the field windings.

OPERATION

The generator armature, M, is assumed to be set into rotation by an external source of power.

To adjust the voltage according to load, the rheostat, R, is carefully regulated, and the brushes, E and F, set in the position of "no sparking." The latter adjustment must have particular attention, for otherwise the commutator or perhaps the armature coils will be burned.

QUES.—How is the current built up in self-excited dynamos?

ANS.—This is accounted for by the fact that a piece of iron which has once become magnetized does not, when the magnetizing influence is removed, become completely demagnetized. A small number of the lines of force remain in the core. These are known as the residual lines of force, i. e., the field poles of the dynamo are said to possess residual magnetism.

When the armature is first set in rotation, its coils cut through the residual field and thereby generate a weak electro-motive force which in turn sets up a feeble current in the field windings. This increases the strength of the magnetic field from pole to pole, which in turn generates increased E. M. F. in the armature coils. This process continues until the normal voltage of the dynamo armature is obtained.

QUES.—How can the voltage of a shunt wound dynamo be increased or decreased?

ANS.—The E. M. F., for instance, can be increased:

(1) By increasing the speed of the armature.

(2) By increase of the strength of the exciting or field current, i. e., by cutting out the resistance at the field rheostat, R.

The reverse operations noted in (1) and (2) will effect a decrease in voltage.

QUES.—What is the limit to which the two foregoing operations can be carried out?

ANS.—The speed of the armature is limited by mechanical considerations such as a safe-bearing speed and safe-centrifugal speed of the armature.

The field current in a given case is limited by the degree to which the iron will saturate, and once this degree of saturation is obtained, an increase of field current will have little or no effect upon the E. M. F. of the dynamo.

QUES.—What proportion of the current generated by the armature flows to the field windings?

ANS.—A very small proportion of the current generated by the armature is taken by the field coils. The requisite magnetizing flux for a given machine is obtained by providing a field winding of a great number of turns through which flows a weak current.

To illustrate: A 2 K. W. 110 v. D. C. machine will have a field current varying from one to three amperes, according to the load. The armature will deliver for external work approximately eighteen amperes.

QUES.—In the case of a shunt wound generator, what effect upon the voltage has an increase of the external load?

ANS.—The voltage will have a tendency to drop off as the load increases.

QUES.—How may this be compensated for?

ANS.—By an increase of the field current through the reduction of the resistance of the rheostat, R, i. e., the handle of the rheostat should be turned in such direction as to reduce its resistance. This result may be obtained automatically by a special winding known as a compound winding.

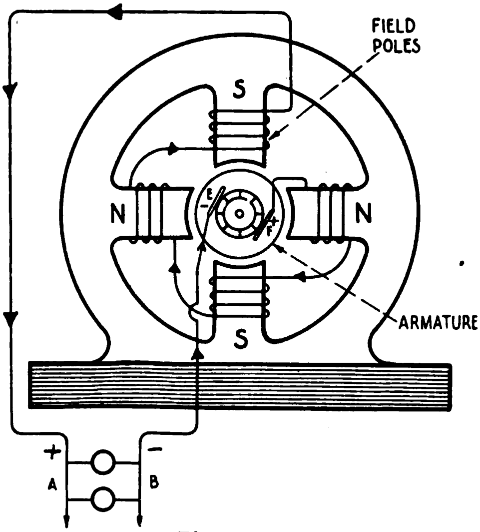


Figure 37

OBJECT OF THE DIAGRAM

To show the general circuits of a series wound dynamo.

PRINCIPLE

By causing the current generated by a dynamo armature to flow through its field windings, the dynamo can be designed to increase its E. M. F. with increase of load.

DESCRIPTION OF THE DRAWINGS

A four-pole generator with the poles N, S, N, S, has the brushes E and F, which rest on a commutator. The circuit from brush F continues through the series winding to the external circuit through the lamp and back to the brush E.

OPERATION

When the armature is in rotation, current flows from brush F through the series winding to the external circuit, provided the external circuit is closed, the circuit continuing to the negative brush, E. If the resistance at A and B be diminished the current through the entire circuit increases. Therefore the field windings will be more strongly magnetized and hence the armature will generate increased E. M. F.

The E. M. F. will increase with the load up to a certain point or until the field is fully saturated. If the load is then greatly increased, the voltage will fall off because the increase of magnetizing flux of the field will not be sufficient to compensate for the drop in voltage.

SPECIAL REMARKS

(1) A series wound generator is particularly desirable for series arc lighting where a constant current is desired with increased voltage as more lights are turned on.

(2) The voltage of a series wound generator may be regulated by cutting in and out turns at the series field winding through the medium of a multi-point switch, or by placing a regulating resistance in shunt to the series winding, thus diverting a portion of the field current.

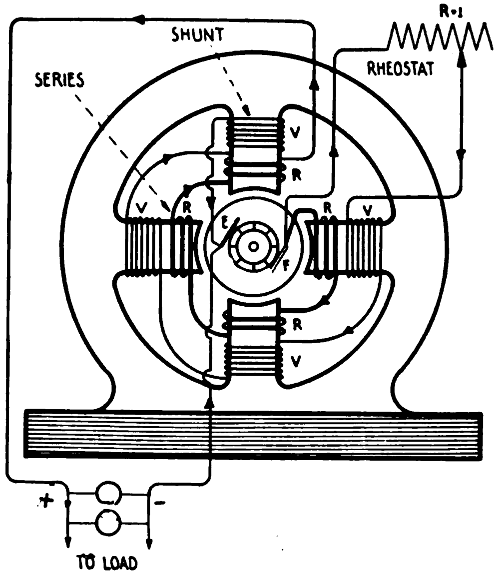


Figure 38

OBJECT OF THE DIAGRAM

To show the fundamental circuits of a compound wound generator or dynamo.

PRINCIPLE

The operating characteristics of the shunt and series wound generator may be combined in one machine.

DESCRIPTION OF THE DRAWING

A four-pole generator has a set of series coils, R, and a set of shunt coils, V, the current circulating in both windings in the same direction.

The shunt winding is tapped across the brushes of the armature and the series winding is connected in series with the brushes of the armature.

A field current regulator or rheostat, R-1, is connected in series with shunt field winding, C, for initial adjustment of voltage.

OPERATION

The initial current for field excitation is supplied by the shunt field coils. As the load on the external circuit increases, there will be a tendency with a shunt winding alone towards a drop in the voltage, but this is counteracted by the series winding. As the load increases, increased current flows through the series winding and the field flux is increased accordingly.

DYNAMO AND MOTOR ARMATURES

(1) The construction or design of dynamo and motor armatures varies widely, according to the nature of the service.

(2) It is not possible in the scope of this course to go over these windings in detail, but a few fundamental facts will be presented showing in a general way the method of winding armatures.

(3) The basic idea underlying the construction of a dynamo armature is to place its coils so as to utilize the north and south magnetic fields, connecting the armature coils in such a way that the **E. M. F. of one coil will be added to that of the remaining coils.**

(4) There are two general types of dynamo armatures.

1. **The ring wound armature;**
2. **The drum wound armature.**

The former type is now practically obsolete.

(5) In the drum type of armature the conductors lie lengthwise on the core 0 (Figure 38), but in the ring wound type they are wound around a circular iron frame (Figure 39).

(6) The windings of alternating current armatures are generally continuous, two final terminals being connected to collector rings.

(7) It is essential that the cores of dynamo or motor armatures be made of thin sheets of iron carefully insulated from one another, for otherwise considerable current will be induced in the iron as well as in the armature conductors. Armatures built up of thin sheets in this way are said to be **laminated.**

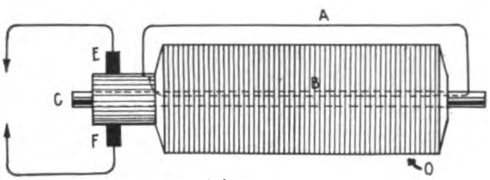


Figure 39

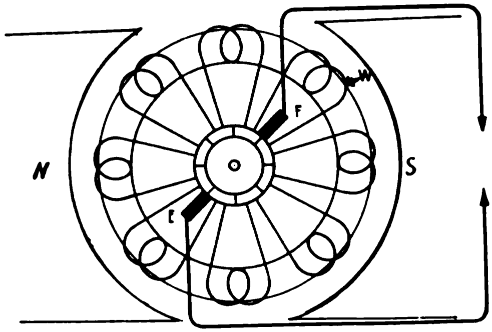


Figure 40

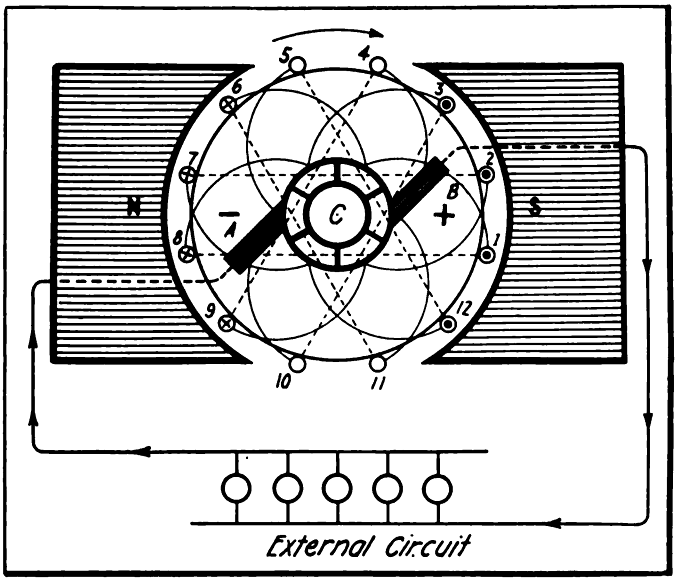


Figure 41

OBJECT OF THE DIAGRAMS

(1) Figure 39 To show the disposition of the coils upon the drum wound armature.

(2) Figure 40 To outline in a general way the construction of the ring wound armature.

(3) Figure 41 To show the actual connections of a simple drum wound armature such as may be employed in a direct current generator.

DESCRIPTION OF THE WINDINGS

(1) In Figure 39 the general shape of the core of the drum wound armature is shown at O. This core consists of a number of sheets of soft iron, properly slotted, which are mounted on the shaft C. The brushes E, F, make contact with the commutator on the left hand end of the shaft. The notations A, B show how a single coil is placed on the armature core The coil is in reality placed lengthwise in a slot cut in the iron.

(2) In Figure 40 the general disposition of the coils on a ring wound armature is shown, a single coil being indicated at W.

(3) In Figure 41 the connections of a drum wound armature are shown for a winding of twelve conductors. Brushes A and B make contact with the commutator C, the external circuit being completed through the bank of lamps.

OPERATION

(1) The following explanation applies to Figure 41. In this diagram conductors 6, 7, 8 and 9 are underneath the north pole, and conductors 3, 2, 1 and 12 underneath

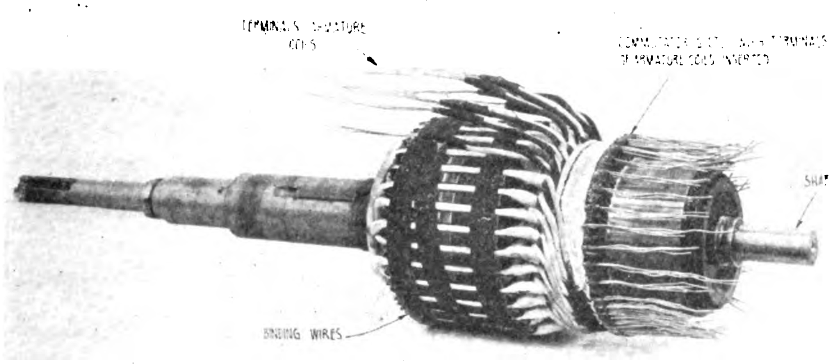


Figure 42

This photograph shows the general construction and disposition of the coils on a direct current dynamo or motor armature of the Crocker-Wheeler type. The terminals of the coil are placed in slots on the end of the commutator bar previous to being soldered. Although the coils on this armature have the general shape shown in Figure* 43, *they consist of double layer windings rather than single windings, as in Figure* 43. *These armature coils lie lengthwise in slots cut in the soft iron core and are held in place by the binding wires shown.

the south pole. If the armature revolves in the direction of the arrow, then the current flows in conductors 6, 7, 8 and 9, to the rear, and in conductors 3, 2, 1, 12, to the front.

(2) Wires 5, 4, 10 and 11 are in the neutral field, and therefore they are not acted upon inductively.

(3) It will be noticed in this diagram that all coils in each half of the armature are connected in series in such a way that the E. M. F. of one coil is added to that

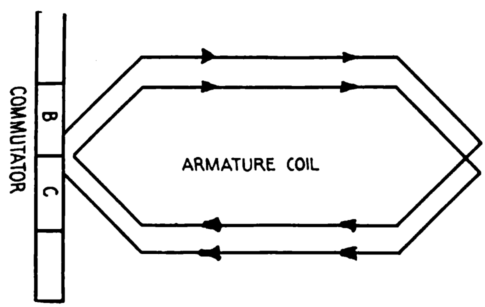


Figure 43

This diagram shows how the terminals of a single armature coil are connected to commutator segments. The complete coil, in fact, consists of two turns, and the current is seen to circulate in the same general direction throughout the coil. Frequently, two sets of such coils are placed in a single set of slots in the dynamo armature.

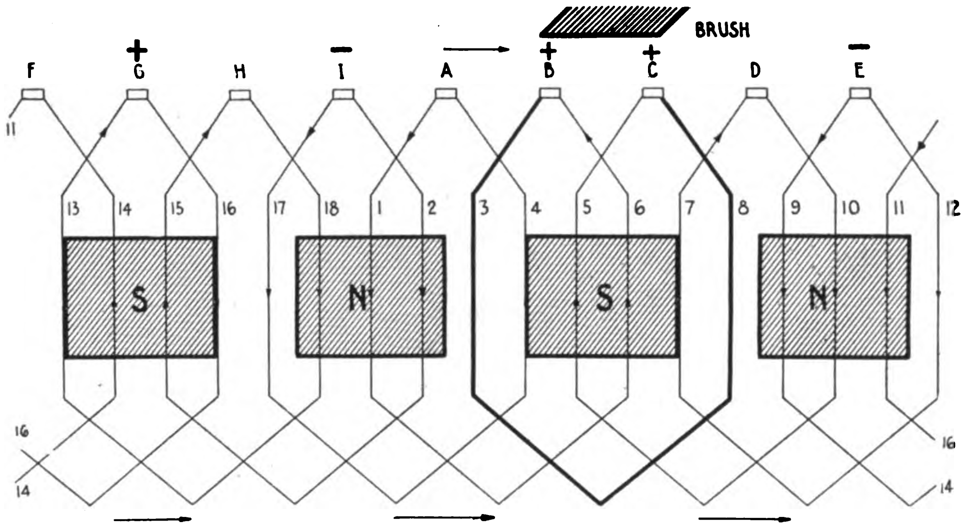


***Figure* 44**

Showing the general outline and connections of a lap-wound direct current dynamo armature. The field poles are represented at N S, N, S, the conductors of the successive coils being numbered 1, 2, 3, 4, etc. This armature consists of 18 conductors, revolving in a four-pole field. Coil 3, 8 is in the neutral field.

We may trace out the direction of the induced current by starting from commutator segment 1, one path being through conductor 17, through 4, to commutator segment A, through conductor 1 and 6, to commutator segment B. The other path is through conductor 2, through conductor 15, to commutator segment A, through conductor 18, through conductor 13, and out at commutator segment B. The current is thus seen to take two paths from the negative brush, through the armature coil, to the positive brush. A similar path is taken from commutator segment E, two paths to the brush D and to the brush G, being indicated.

---

of the next; that is to say, the wires are joined together in such a way that the circuit is continuous. This can only be accomplished by selecting as a pitch (for the connection) a number which is one greater or one less than one-half of the total number of conductors. In this case we have selected as a pitch 5. The connections of the armature conductors at the rear are indicated by the dotted lines.

(4) The circuit may be traced out as follows

Front: wire 8 is joined to wire 3.
Rear: wire 3 is joined to wire 10.
Front: wire 10 is joined to wire 5.
Rear: wire 5 is joined to wire 12.
Front: wire 12 is joined to wire 7.
Rear: wire 7 is joined to wire 2.
Front: wire 2 is joined to wire 9.
Rear: wire 9 is joined to wire 4.
Front: wire 4 is joined to wire 11.
Rear: wire 11 is joined to wire 6.
Front: wire 6 is joined to wire 1.
Rear: wire 1 is joined to wire 8,
the latter being the wire at which we began.

The next point to be observed is that this winding is in reality composed of two windings in parallel from brush to brush, as we shall presently see.

(5) Beginning with the negative brush, we may trace the circuits in two directions; one path leads to wire 5, the other to wire 10.

The following paths will be noted:
5-12-7-2-9-4 positive brush;
10-3-8-1-6-11 positive brush.

(7) That is to say, the current flows in the armature coils in both paths away from the negative brush and towards the positive brush.

(8) It is well to keep in mind that this diagram represents the simplest possible type of drum wound armature and that many other types are in commercial use. Careful study of this diagram will reveal the function of the commutator.

(To be continued)

A Digest of Electrical Progress

The Experiments of Marconi's Predecessors in Attempting to Establish Wireless Communication and How Marconi Found the Road to Success—Early History of Land Line Telegraphy and Cable-Laying—Using a Pliotron Oscillator for the Production of Large Currents at Radio Frequencies—The Movement to Establish the American Academy of Engineers

WIRELESS AND EARLY SYSTEMS OF TELEGRAPH COMMUNICATION

IN an article entitled "Wireless Points and Pointers," in *The Railroad Man's Magazine,* Samuel W. Beach shows that although many scientists conducted investigations with a view to establishing communication without wires, none succeeded until Marconi announced his discovery of electric wave telegraphy. The experiments of his predecessors were mainly confined to earth current and electrostatic induction systems, and although Hertz in his early work proved the existence of electrical waves, his apparatus could by no means be applied to communication, even over distances of a quarter of a mile.

The writer asserts that Hertz not only did not grasp the true value of his work, but he actually smiled at the suggestion made by the engineer, Huber, that his electrical waves might be harnessed and employed for signalling through space.

After citing experiments made by other investigators, among them Maxwell, Lodge and Branley, he says:

> "What Sir Oliver Lodge failed to get, another man there was who eagerly grasped it. He was just a youth, looking none too healthy, and with a nervous temperament. He was an Italian immigrant—born in Bologna, April 25, 1874, of Irish-Italian parentage. It is said that he looked like anything other than a great inventor when he wandered into the office of Sir William Preece, in England, and introduced himself as Guglielmo (William) Marconi.
>
> "Fortune not only smiled, but literally laughed upon this wonderful man from the very start. With the willing assistance of Preece, Marconi's ideas and apparatus grew apace so rapidly that it stuns the mind to read of it."

The writer declares that on September 12th, 1901, Marconi and an assistant, Kemp, received at a station at Signal Hill, St. John's, Newfoundland, the letter S many times repeated sent by a station at Poldhu, Cornwall, 1,800 miles distant across the Atlantic ocean. He says:

> "So rapidly did wireless advance that at eight o'clock on the morning of December 9, 1916, the big wireless station at Arlington, Virginia,

distinctly heard Japan working with Honolulu. The distance lacks but a few degrees of being half-way around the globe.

"Marconi first spanned the big pond without wires. Other inventors, plenty of them, such as Fessenden, deForest, Slaby, and Shoemaker, have done wonders; but the name of Marconi shall outlive them all."

Mr. Beach declares that Morse's supposed priority in the invention of land line telegraphy is generally misunderstood. He says that the wire telegraph system first saw the light of day at Geneva, Switzerland, some two or three years before the battle of Bunker Hill, and at least twelve telegraph lines are said to have been in fairly successful operation in Europe when Morse sent his famous message to Washington in 1844. But notwithstanding the fact that Morse's apparatus was built from theories already advanced, it so outclassed the apparatus of his predecessors that all other schemes sank into oblivion.

The cable laid by Cyrus W. Field was not the first to span the Atlantic, Mr. Beach asserts. He declares that the cities of Dover, England, and Calais, France, have the distinction of having been the terminals of the first submarine cable, which was laid in 1844. It was approximately twenty-five miles in length, and was operated for almost twelve years before repairs were necessary. Field's first cable between Trinity Bay, Newfoundland, and Valencia, off the coast of Ireland, ceased to work after it had been in operation sixteen days, but its usefulness was thoroughly proven, for one cablegram alone during this period saved the English government more than $250,000.

Among the humorous instances of attempted telegraphic communication, that of the eminent Spanish electrician, Don Francisco Salva, in 1795, is perhaps the most amusing. Salva advocated the construction of a telegraph line between Barcelona and Mataro, which was to consist of forty-four wires, that is, twenty-two complete metallic circuits. Mataro was to be the receiving station, and twenty-two men were to be stationed there, each grasping the broken end of the metallic circuit. Each circuit stood for a particular letter of the alphabet and the signals were to be sent by discharging a Leyden jar into whatever circuit bore the particular letter to be signalled. This was expected to throw a shock into the human sounder at the distant terminal, who bawled out the letter which had been apportioned to him.

It is generally recorded that Professor C. A. Steinheil of Munich first discovered the feasibility of using the earth for the return circuit in wire telegraphy. But it is fully established that the conductive properties of the earth were known many years before Steinheil's work. In fact, Aldini, as early as 1803, used the waters of Calais harbor for the return circuit.

A PLIOTRON OSCILLATOR FOR THE PRODUCTION OF LARGE CURRENTS AT RADIO FREQUENCIES.

STUDENTS of radio communication are thoroughly familiar with the use of the pliotron evacuated bulb of the General Electric Company as a detector and amplifier of radiotelegraphic signals. They are also aware that such bulbs may be employed to convert direct current into alternating current of any desired radio frequency, but they rarely have an opportunity to see pub-

lished a detailed diagram of its connections or the constants of the circuit specially suited for a given service. Especial interest, therefore, attaches to a recent article by William C. White in the *General Electric Review.*

The writer points out that in a resonance circuit the current will rise until the losses become equal to the input energy, but with practical circuits the lower limit of power-factor obtainable is about one-half of one per cent. This permits the maximum resonance current produced to be about 200 times the value of the true energy current fed into the resonance circuit. In consequence, if large currents are desired from a small quantity of energy, the total volt-amperes of the circuit must be kept small. This condition requires that for such a resonance circuit, a large capacity and small inductance must be used. Again, if the amount of electrical energy which can be furnished by a certain source is limited by the definite amount of primary power available, or by the losses in transmission, it is important that the resistance of the load be adjusted to the voltage so that the energy will be economically utilized. This implies that the resistance of the heavy current circuit must give an apparent value most suitable for insertion in the pliotron anode circuit.

Two methods are shown by which a single pliotron bulb can be made to generate either a heavy current or a high voltage current at radio frequencies for calibration purposes.

In Figure 5, the complete circuits of the pliotron bulb are shown inductively coupled to a resonance circuit, including a calibrated ammeter, A, and a second Ammeter, A^1, which has been inserted for calibration, and as usual the frequency of the circuit, L 3, C 3, A^1, A, is determined by the usual resonance equation:

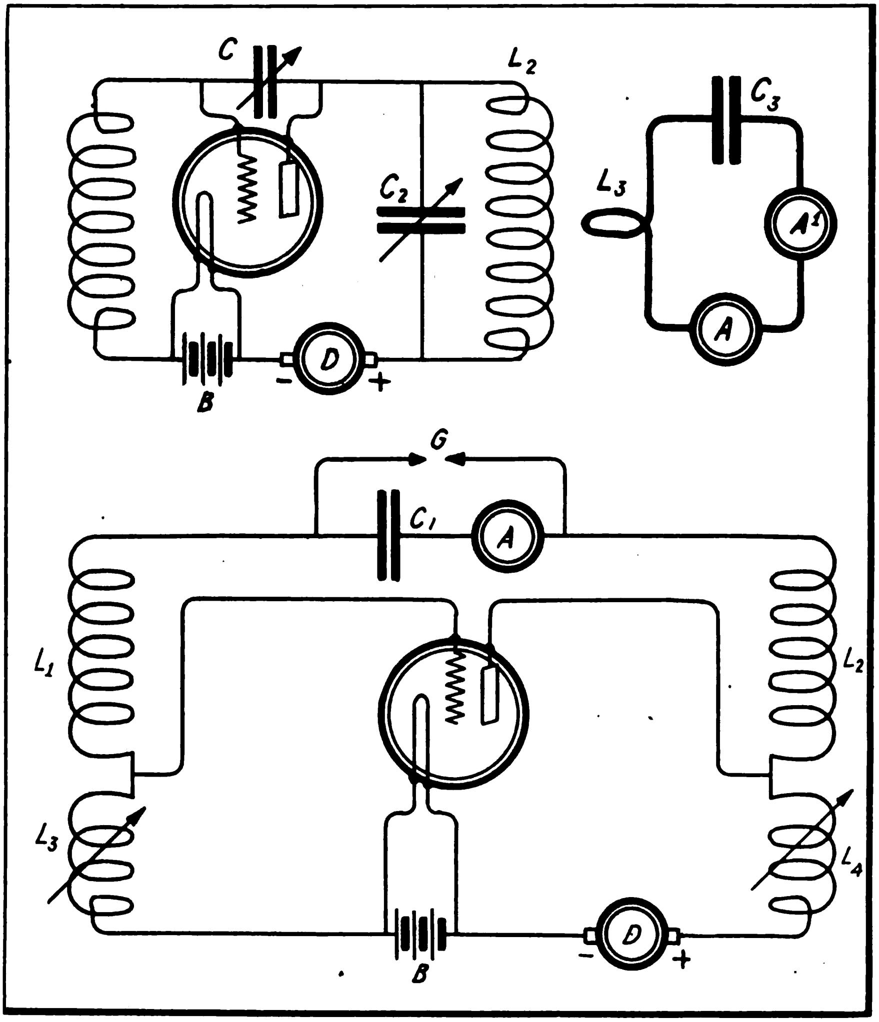
$$N = \frac{1}{2\pi\sqrt{LC}}$$

It is important in a case of this kind that the inductance value of L3 be made the minimum possible; usually it consists of one or two turns of heavy conductor and, therefore, the value of the condenser, C3, must be of the order of 0.1 microfarad.

By proper adjustment of the inductance of L1, L2, and the capacity of the condenser C1, the pliotron circuit of Figure 5 can be made to set up a high frequency current having a frequency corresponding to the period of the heavy current circuit. Because of the relative values of the inductances, L2 and L3, the apparent resistance in the plate circuit is greatly multiplied, but this is not sufficient to absorb all the available energy, and to increase this apparent resistance further, a variable capacity, C2, is shunted about the inductance L2.

The output of the circuit indicated in Figure 5 is dependent upon the voltage of the direct current source, and the useful range has been found to be between 200 and 750 volts. With this arrangement, current can be obtained at frequencies of from 100,000 to 1,000,000 cycles per second. It is declared that pliotrons may be operated in parallel to produce a current larger than that obtainable from a single bulb.

The circuits of the pliotron oscillator for the production of high voltages at radio frequencies are shown in Figure 6. Here the inductances, L-1 and



Figures 5 *and* 6

L-2, are approximately eight millihenries each. Inductances L3 and L4 are of approximately 2.5 millihenries. They should be, if possible, of the variometer type, but a simple coil fitted with a number of variable contacts will be satisfactory. As usual, the direct current dynamo is indicated at D, the high voltage condenser at C1, and the spark gap at G. The capacity of C1 should lie between twenty and 200 microfarads for a frequency of 100,000 cycles. Through use of a hot wire ammeter, A, and knowledge of the frequency, the voltage produced across the condenser, C, may be simply calculated.

If the values of the inductance and capacity are properly proportioned for a frequency of 100,000 cycles, and the voltage of the dynamo lies between 200 and 750 volts, voltages up to 12,000 may obtain. It is further mentioned that two metal plates, 10 inches by 10 inches, placed approximately ½ inch apart, will afford a condenser having a capacity of approximately forty microfarads.

It is difficult to say in how many ways the pliotron bulb will lend itself

to practical application, but present indications point to the fact that it will be an indispensable adjunct to the laboratory of the modern radio experimenter.

THE AMERICAN ACADEMY OF ENGINEERS

IN order that the United States Government may have an able body of engineers to act in an advisory capacity as occasion arises a bill recommending the incorporation of an institution to be known as the American Academy of Engineers was recently considered in the United States Senate. The establishment of this body has been under consideration for eight years, and due to the present national crisis, its immediate organization was urged by prominent engineers throughout the country.

The objects of the organization may be summed up as follows:

1. To render loyal and effective service to the United States Government so far as lies within its power.

2. To advance in every legitimate manner the interests and welfare of the engineering profession in all its numerous branches.

Limited to a membership of 200, we find among the names of the fifty original incorporators, such men as Dr. John J. Carty, chief engineer of the American Telephone and Telegraph Company; Howard E. Coffin, vice-president and chief engineer of the Hudson Motor Company, and member of the Naval Consulting Board; Dr. John J. Hammond, past president of the American Institute of Mining Engineers; Herbert C. Hoover, food administrator of the United States Government; Dr. Elihu Thomson, past president of the American Institute of Electrical Engineers; Dr. M. I. Pupin, member of the National Academy of Science and Professor at Columbia University; Frank J. Sprague, past president of the American Institute of Electrical Engineers; Dr. William Barclay Parsons, consulting civil engineer, New York City.

One of the articles of incorporation specified:

> "That the American Academy of Engineers shall, whenever called upon by any department or establishment of the government, investigate, examine, experiment, and report upon any subject of engineering science or art, the actual expenses of such investigation, examination, experiment, and report to be paid from appropriations which may be made for the purpose; but neither the Academy as a body or any of its committees shall receive any compensation whatever for any service to the government of the United States."

Dr. C. O. Mailloux, past president of the American Institute of Electrical Engineers, wrote a stirring letter to Congress, saying that an institution developed in France along similar lines, known as the Academy of Agriculture, had been established with beneficial results to the government. During the last two years, he said, efforts have been made to establish in France a federation of engineers, architects, and technologists with the object of insuring a better co-ordination of and co-operation among the different branches of applied science. So far the efforts to bring together this organization had not borne fruit.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS
Instructions for Designing a Step-Down Transformer

No wireless amateur who wishes to succeed can limit himself to the construction of a wireless telegraph equipment alone. He should, in fact, investigate other branches of electrical practice, because as he will see sooner or later, the operation of modern wireless telegraph apparatus is based on certain fundamental electrical principles. Moreover, the commonly used wireless telegraph equipment is made up of certain parts which were well known to the electrical trade previous to the advent of wireless telegraphy.

One of the pieces of apparatus for which the average electrical experimenter often has great need is a step-down transformer, but to date very little data giving instructions for its construction have been published. The purpose of this article is to describe such a transformer in terms simple enough to satisfy the most inexperienced amateur. Moreover, this transformer, when completed, will have a wider range of power, that is, it will be more flexible than the type ordinarily supplied to the amateur market. Its cost will also be less.

In calculating the frequency of a transformer, it is necessary to take into account numerous factors, either contributing to or against perfection. A far-reaching discussion of this point is beyond the scope of this article, but after considering the sum of all the defects in the average amateur-built instruments, it is safe to predict an operating efficiency of ninety per cent., that is to say, the secondary winding will give ninety per cent. of the total energy taken in at the primary winding.

The transformer is designed to have a maximum output of 250 watts (¼ K. W.) and it is clear that in order to have an efficiency of ninety per cent. the total required input will be 275 watts. It is expected that this transformer will be connected to a 110-volt supply of alternating current; therefore, to determine the size of wire necessary to carry the primary current, without heating, the simple formula amperes=watts÷volts is used.

If we assumed 275 watts as the input, then the required current would equal 275÷110 which is 2.5. To determine the size of wire to carry this current, we must multiply by 1,000, that is, 1,000×2.5=2,500 which is the cross sectional area of the copper wire required to handle the current of 2.5 amperes. By reference to a standard wire table, we find that No. 16 wire has the requisite current-carrying capacity.

In calculating the size of the secondary winding, identically the same method is employed. If the builder expects the transformer to have a maximum output of 250 watts, with the highest step giving fifty volts, he will have to wind the secondary with wire large enough to carry five amperes, because 250÷50=5. Multiplying five by 1,000 equals 5,000 circular mils which is the cross sectional area of the required wire. Again, referring to the wire table, it will be found that No. 13 wire is called for.

We have mentioned that in order to obtain an efficiency of ninety per cent. an input of 275 watts is required; therefore the difference between this and the

output or twenty-five watts must be lost somewhere in the process of transformation. This loss is due to eddy currents, hysteresis in the iron core and heating of the windings.

Laboratory investigations have shown that about forty-five per cent. of the total or 11¼ watts, are due to the first two of these losses of which seventy-nine per cent., or 8.89 watts, are accredited to hysteresis alone. This latter loss, 8.89 watts, is called the iron loss and the core must have sufficient volume to dissipate this amount. The standard practice is to allow 0.15 watt loss to each cubic inch of core. Therefore, to find the required volume of iron we divide 8.89 by 0.15, which gives fifty-nine cubic inches. This loss is calculated upon the presumption that the core was built up of shellac insulated iron laminations.

The writer's attention has been called to the fact that some of the large manufacturers of transformers place their iron in a brine solution in order to put a coat of rust on it. This is a simpler method and should give as good results. In the construction of transformers it has been my custom to use No. 28 stove pipe iron for the core. This can be picked up in any tin shop out of the scrap. The shellac, or rust, is used to prevent excessive losses due to eddy current being induced in the core.

No hard and fast rules can be laid down for designing the core, but it must be made long enough to accommodate the windings and wide enough to prevent the coils touching in the center space. The core should not be extremely long as it would tend to increase the reluctance of the magnetic circuit, although it would require an excessive number of turns on the winding which is detrimental to efficient operation. A good plan is to keep the core nearly square, never allowing the length to exceed greatly the width. A convenient size for the transformer under discussion is 9 inches by 7 inches outside dimensions, with a cross section of 1½ inches by 1½ inches. The core will then have a total volume of 58½ cubic inches.

In assembling the core of the transformer, start with the long leg, that is, the pieces 9 inches by 1½ inches. Then place on this a piece 6 inches by 1½ inches, leaving a space of 1½ inches at each end. This space will take the ends of the short legs which are laid crosswise. Lay up enough pieces alternately 9 inches by 6 inches until a pile of 1½ inches is obtained. These should then be pressed tightly together with a clamp, and wound with two layers of friction tape.

One half of the total number of turns of wire in the primary is wound on each leg. The required number of turns is found by using the formula:

$$\text{Turns} = \frac{\text{Voltage} \times 10^8}{4.44 \times F \times f}$$

where 4.44 and 10^8 are constants. In this case, the voltage is 110, the frequency, f, is 60 cycles. F refers to the flux or the number of magnetic lines of force passing through the core. This quantity is obtained by multiplying the cross sectional area of the core (1½ inches by 1½ inches) by the maximum flux per square inch. The standard flux for sixty cycle work is 30,000 lines per square inch. Then 1½ by 1½ by 30,000 =67,500. Substituting in the above formula, we have

$$\text{Turns} = \frac{110 \times 100{,}000{,}000}{4.44 \times 67{,}500 \times 60} = 612$$

Care should be taken to wind the primary coil on each leg so that the current will travel around the core in the same direction; otherwise the current in one leg will oppose that in the other, and the transformer will not work.

In my estimation the best way to wind a transformer by hand is to clamp the core in a vise, fastening one end of the wire on the core and leaving a lead about 1 foot in length. The core should then be wound to the right. Both legs are wound in the same direction. After the primary and secondary windings are made complete, the core construction is completed by adding two short legs. The inside or the starting leads of the primary winding are then connected together.

We have stated that No. 13 wire was required to give an output of fifty volts and five amperes. Theoretically, a different sized wire could be used for each step in voltage to keep the ampere high enough to give the maximum output in

watts. This is done, however, only in special cases. In this design the output in watts is divided by the highest step in voltage, and the same sized wire is used throughout all steps.

The next step in the order of construction is to find the number of turns for each step in voltage and output from the secondary. This is obtained by the following formula:

$$\frac{\text{Volts input}}{\text{volts output}} = \frac{\text{turns on secondary}}{\text{Turns on primary}}$$

substituting, we have

$$\frac{110}{50} = \frac{612}{X}$$

therefore X=279 turns.

This is the total number of turns required to give an output of fifty volts and five amperes. Whatever voltages the builder requires may be figured out in the same way, taps being taken off the windings to include the number of turns shown by the calculation.

The number of turns for a very good run of voltages are given in the following table:

Steps	Turns	Volts
1 to 5	279	50
1 to 4	223	40
1 to 3	167	30
1 to 2	·139	25
2 to 5	140	25
2 to 4	84	15
2 to 3	26	5
3 to 5	112	20
3 to 4	56	10
4 to 5	56	10

Before winding the secondary, the primary should be covered with two layers of empire cloth. Also it should be noted that half of the secondary is wound on each leg over the primary. It should be wound so that the number of turns will work out so that the inside or starting end on one leg will be connected to the inside end on the other leg. This transformer can have a special winding for a particular amperage by winding a separate coil on the short legs.

I am sure that an amateur building a transformer after this design will have one that will give perfect satisfaction.

J. E. MacGregor, *Michigan*.

SECOND PRIZE, FIVE DOLLARS

Novel Capacity Tuning Which Has Proven Successful

The article in the July issue of The Wireless Age on "Novel Design in Receivers," interested me considerably because I have been working along similar lines. My developments originated from another experimenter of New York City and I have further amplified their use in conjunction with regenerative vacuum valve circuits. The scheme has proven very efficient both in selectivity in tuning and in amplifying radio-frequency currents.

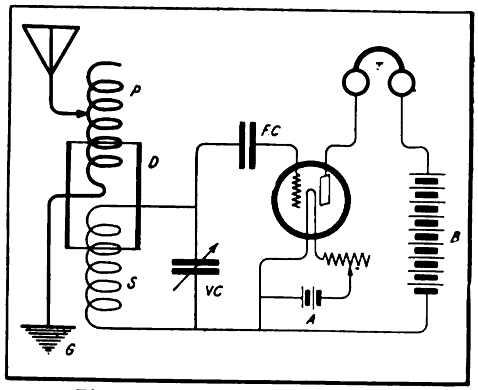


Figure 1—Second prize article

A wiring diagram similar to that of Elmer E. Bucher's was used, but it did not seem to increase the audibility of signals as mentioned in the article referred to. For this reason another arrangement of circuits was adopted, i. e., the principle of capacity coupling was utilized for coupling the wing circuit to the grid circuit of the valve. Accompanying this article is a photograph of the capacitively-coupled tuning coil which has been used in these experiments, and in addition three circuits which have proven very satisfactory. The explanation for each individual circuit will be gone over for the benefit of those who desire to investigate further.

The first of these circuits is shown in Figure 1. The metal disc, D, placed

over the two windings of an inductive coupler, travels back and forth at a distance from the coil by mounting it over a sliding rod, as shown in the photograph. The inductive coupler used in this experiment consisted of two windings, each wound side by side on the same core. It was found that by tuning the primary of the coupler to the re-

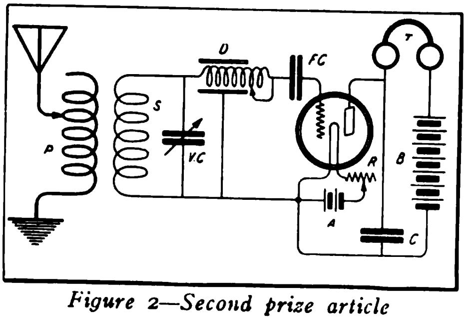


Figure 2—Second prize article

quired wave-length of the received signal and then carefully coupling the two circuits electrostatically that is, adjusting the metallic disc, D, between the two circuits, increased strength of the signals was obtained. This was probably due to the increase of coupling between the circuits, thus increasing the energy transformation.

This circuit was found to be of considerable value in preventing interfer-

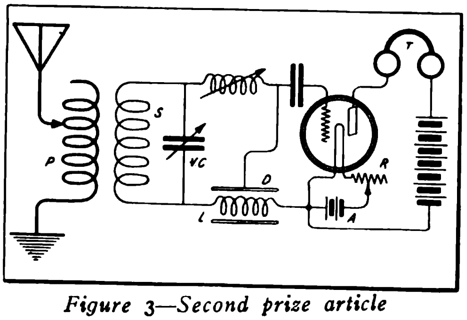


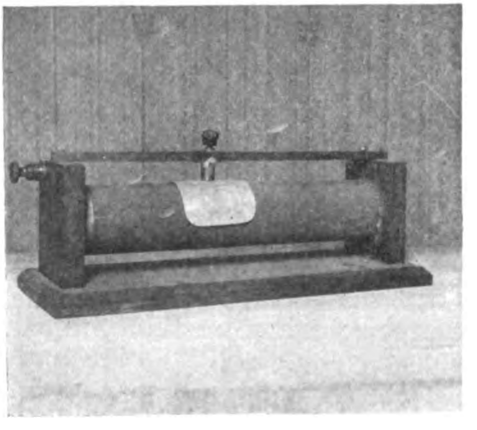
Figure 3—Second prize article

ence. Arc light disturbances were lessened to such an extent that the circuit is strongly recommended to those who are constantly experiencing this interference.

If a regenerative circuit is employed, such as shown in Figure 2, it is found that by placing a metallic disc, D, over the tuning coil, L, the adjustment for the oscillating condition could be more readily found. It was further observed that outside capacity efforts were unable to disturb the oscillating condition of the system, as is frequently found to be the case in ordinary regenerative circuits.

A circuit somewhat similar is shown in Figure 3, where the tuning coil, L, is linked in series with the filament terminal of the valve. Although this scheme did not prove to be an efficient amplifier, it was an excellent oscillator and was therefore used mostly for undamped wave reception. The usual metallic slider, D, was employed.

It is hoped that these circuits will some day find their way into the modern amateur's station. He will certainly



A photograph of the tuning coil used in the experiments described in the second prize article.

find them of great assistance in long-distance reception.

SAMUEL COHEN, *New York.*

Editorial Note.—Fully appreciating the writer's early work in this direction, we suggest that he note the date of the specification granted to Elmer E. Bucher on electrostatic tuning.

The conditions brought about in the amateur field as a result of the war provide contributors to this department with excellent opportunities to evolve ideas for articles. It is fairly well established that in the battle fields abroad emergency apparatus must be constructed of whatever material may be available. The ingenuity displayed by experimenters in putting together apparatus should not only give valuable suggestions to signal men, but there may appear in these pages at some time the exact solution of a problem confronting the soldier in the field.

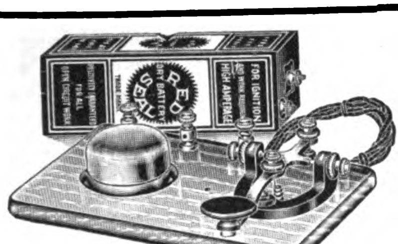
The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

IT is within the range of possibility that the uninformed amateur experimenter may unintentionally violate the President's executive order in regard to dismantling his wireless apparatus. The following communication from the United States Navy Department calls for attention on the part of the members of the N. A. W. A.:

> It has come to the notice of the Navy Department that the President's executive order which called for the dismantling of private radio stations, has been misinterpreted by many experimenters, publishers, and amateurs.
>
> By dismantling is meant *the complete disconnection of all pieces of apparatus and antennae, and the sealing and storing of same.* Apparatus which is not dismantled as outlined above is subject to confiscation.
>
> A number of articles have been published urging experimenters to use phantom antennae for experimenting and improving their equipments. In order to do this the experimenter must connect up his apparatus and this is contrary to the dismantling order.
>
> Will you please bring this to the attention of your large number of readers in order to enlighten them as to what is meant by the President's order relative to the closing of all private radio stations.

The precautions taken by the Navy Department to prevent hostile radio communications are entirely in order, and it behooves all experimenters to co-operate with the Government and comply with the President's order to the smallest detail. It is clearly evident that amateurs who attempt to rebuild or improve their apparatus take the risk of meeting with punishment and having their equipments confiscated. Note that by dismantling is meant "the complete disconnection of all pieces of apparatus and antennae and the sealing and storing of same." Obviously, apparatus under construction comes within the scope of this order. Therefore the members of the N. A. W. A. and other experimenters are not only directed to discontinue the construction of such apparatus, but they are also urged to avoid building apparatus that is in any way suggestive of a radio telegraph set.

There is nothing in this order of the Navy Department, however, which prevents the amateur from studying wireless from a practical or engineering standpoint. In fact, as we have repeatedly brought to our members' attention,



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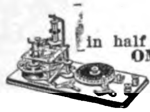

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present conditions offer them an unusual opportunity for improving their knowledge of the art. They are advised to follow the instructional articles appearing in this magazine and to purchase text books bearing on the subject. Not only will they be better equipped to operate their own apparatus when the time comes, but in the event that emergencies demand it, they will be able to serve their country better as wireless telegraphers.

The Army and Navy Departments require hundreds of expert radio telegraphers—men who have the ability to co-ordinate theory and practice. Some have natural ability along these lines, while practice is required to develop it in others.

Military affairs are engaging the attention of N. A. W. A. members more than ever, and it would seem from the communications received that the rating of army and navy officers is one of the least understood subjects. The ranks of the various officers in relation to each other are shown as follows:

Army.	*Navy.*
General	Admiral
Lieutenant-General	Vice-Admiral
Major General	Rear-Admiral
Brigadier-General	Commodore
Colonel	Captain
Lieutenant-Colonel	Commander
Major	Lieutenant-Commander
Captain	Lieutenant
First Lieutenant	Lieutenant (Jr. Grade)
Second Lieutenant	Ensign

No one at present in the United States Army holds the rank of general. This rank exists only when specially created by Congress, and so far has been filled but four times in United States history. The title of admiral was only conferred once, when it was given to George Dewey by special act of Congress.

Since the President's declaration of war, schools of wireless instruction have been opened in numerous cities. Some were instituted by private individuals and others were established under government supervision. While amateurs throughout the country constitute a great part of the students of these schools, many who enrolled had not heretofore been engaged in signalling work of any sort. The land line telegrapher, too, while quick at the telegraph key, is frequently unable to grasp the technical details of radio apparatus. He finds that although knowledge of land line telegraphy is by no means unimportant, the wireless operator's curriculum includes considerably more than ability to manipulate the telegraph key.

One of the errors made by some students is their attempt to master the manipulation of wireless apparatus without knowledge of elementary electricity and magnetism. Others, possessing more foresight, take up elementary work and slowly but surely master the rudiments of the art; thus working on a solid foundation they find themselves easily able to qualify as operators.

The student located far from a training school is at a disadvantage. He does not find it difficult to master the transmission of the code signals; in fact, he could learn to send the code characters with two or three days' practice, but when it comes to the matter of receiving, he will find himself in need of a second student who will send to him slowly until he is able to recognize the characters transmitted. In case such a helper is not available, an automatic sender can be resorted to, but the difficulty with a transmitter of this type is that one soon becomes familiar with the words on the record, and consequently can form the complete word or sentence before it is finished. This does not give actual practice, but, of course, if a number of records are available, the difficulty can be partly overcome.

Experience teaches that once the experimenter has gained a certain speed, the services of a competent instructor are necessary if further progress is to be attained. It should not be difficult for the average student to find a land line telegrapher who, with a few days' practice, can master the Continental code characters and send to the student for hours at a time until the latter becomes proficient in receiving signals. Steady application and daily practice over a period of, say, five months should qualify the average student to become a capable Continental code telegrapher.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

N. A., Philadelphia, Pa.:

We do not clearly understand your communication of recent date with reference to the proposed method of varying the inductance of the secondary winding of a receiving transformer. It is not absolutely necessary to adjust the inductance of this circuit by single turns. In fact, if a shunt secondary condenser is employed, taps can be taken from every tenth or fifteenth turn. Whether or not your device has merit we cannot say unless we see a detailed diagram showing how it functions.

* * *

H. J. H., Atlantic City, N. J., inquires:

Ques.—(1) What size wire do you consider to be the best for connecting up transmitting and receiving apparatus for wireless telegraphy?

Ans.—(1) The low voltage alternating current power circuits should be connected up with No. 12 or No. 14 single braid rubber covered wire. The circuits of radio-frequency such as the condenser, spark gap and oscillation transformer should be connected together with stout stranded copper wire or copper tubing. The receiving apparatus may be wired up with rubber covered annunciator wire which possesses sufficient conductivity for this work. The connections from the oscillation transformer to the earth lead of the transmitting apparatus should be made of copper ribbon, if possible.

Ques.—(2) Will a flat top antenna have greater efficiency in sending and receiving if it is slanted a few degrees out of the horizontal?

Ans.—(2) It is doubtful whether slanting it will make any difference.

Ques.—(3) Please explain how a wave-meter can be used to tune receiving apparatus.

Ans.—(3) This method is fully described in the textbook, "Practical Wireless Telegraphy." A wave-meter is set into excitation by a buzzer and battery and its inductance coil is placed in inductive relation to the earth lead of a receiving set. The wave-meter now becomes a miniature transmitting set which acts inductively upon the receiving set. The wave-meter is then set at a particular wave-length, following which adjustments are made of the inductances and capacities of the receiving set until maximum response is obtained. The wave-length of the receiving set obviously is that of the wave-meter. To make such calibrations with a fair degree of accuracy, the coupling between the wave-meter and the circuit under measurement should be as loose as possible.

* * *

K. R. A., Newark, N. J.:

The best electrolytic interrupters are made by immersing a lead plate with a piece of platinum wire in a diluted solution of sulphuric acid, the amount of acid employed depending upon the voltage of the current and the rate of interruption desired. It is customary to insert the platinum in a porcelain tube and provide means whereby the amount of platinum exposed to the acid can be carefully regulated, that is to say, the electrode can be raised or lowered by a thumb screw adjustment.

One concern manufactured, several years ago, a very satisfactory interruptor, which, instead of employing a platinum rod for the anode, used a long piece of German silver wire. This was fed through the porcelain sleeve by a long spiral spring and at the bottom of the tube the German silver wire rested upon a porcelain button. The amount of German silver exposed to the action of the acid was governed by a small regulating screw which raised and lowered the porcelain sleeve.

Two disadvantages arise in the use of the electrolytic interruptor, one being that it will become overheated unless it is water jacketed, and the second that it is somewhat dangerous to operate. In several instances violent explosions have occurred, due to the accumulation of hydrogen gases, but if the interruptor is placed in a closet at a distance from the apparatus being operated, safety is assured. It is possible to secure an extremely high rate of interruption with this device, particularly when di-

rect current is employed, but the electrolytic interruptor will not function well on voltages of less than eighty volts.

* * *

A. C., Paris, France, inquires:

Ques.—(1) You will note from the diagram of a receiving set accompanying this query that a telephone transformer is shunted around the blocking condenser in

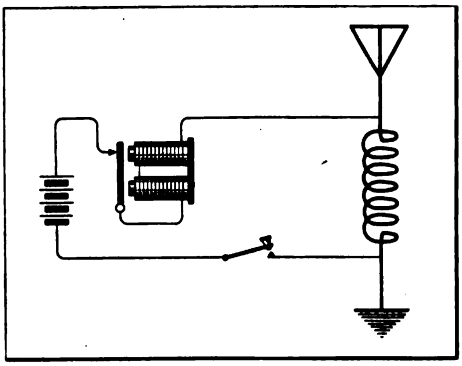

Figure 1

the local circuit, and the secondary winding of the transformer is connected to a telephone. Would this arrangement increase the strength of signals? If so, please state the dimensions of the transformer suited for this purpose.

Ans.—(1) The step-down telephone transformer will only increase the strength of signals in the event that a high resistance detector is employed and a low resistance telephone only is available. In such a case, increased strength of signals would be obtained, but if a high resistance telephone having sufficient ampere turns to give a resistance of 3,000 ohms is employed, better signals will be obtained without the step-down transformer. You, of course, understand that there are certain energy losses in transformation in any type of transformer, and, therefore, no benefit would be derived in adopting a step-down transformer except under the conditions mentioned.

Ques.—(2) I have frequently heard the statement and have also seen it published in your magazine that an ordinary bell buzzer can be employed for radio transmission. What would be the normal transmitting range of such a buzzer, and how should it be connected to be most effective? Is a condenser necessary?

Ans.—(2) Two methods of connection for this buzzer are shown in Figures 1 and 2. In Figure 1 the circuit of the bell buzzer is completed through a coil of fifteen turns of annunciator wire connected in series with the antenna circuit. In Figure 2 a .005 microfarad condenser is connected in series with the antenna and in shunt to the vibrator of the buzzer. Connected in either way, the antenna will be charged at a rate depending upon the speed of interruption of the vibrator.

The actual range of such apparatus depends upon the sensitiveness of the receiver. It has frequently been possible for battleships to communicate at sea over distances of thirty miles when the receiving station was equipped with a triple vacuum valve amplifier.

We do not quite understand the drawing accompanying your third query, which apparently shows two tuning coils, A, B, in parallel and both in series with the antenna circuit. We see no advantage in this arrangement whatsoever.

Answer to fourth query: We have made some calculations on your antenna which, by the way, is rather difficult to calculate on account of its irregular shape; but if it consisted of four wires, its capac' be about .0022 microfarad. If you wish to calculate the capacity of wireless telegraph antennae, and you have sufficient knowledge of elementary mathematics to carry out the work, you should secure a copy of the book entitled "The Calculation ar Measurement of Inductance and Capacity," by W. H. Nottage, which can be purchased from the Wireless Press, Ltd., Marconi House, Strand, London, England.

Answer to last query: The actual size of the antenna wire does not make much difference provided it possesses sufficient current-carrying capacity for the power of

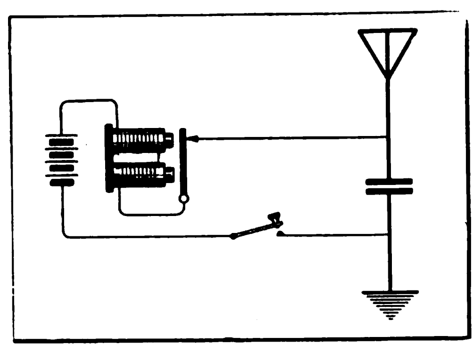

Figure 2

the transmitter employed. It is customary in the United States to employ a conductor made of seven strands of No. 19 silicon bronze wire. This wire is not employed because it possesses a particularly high degree of conductivity, but because it possesses great tensile strength which is highly important when we consider the span of the antenna on many ships. We consider your antenna too long for the reception of signals around 600 meters, but for the copying of signals from high-power stations, he antenna you mention will be satisfactory.

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Edward J. Nally, Pres. Charles J. Ross, Vice-Pres. David Sarnoff, Secy. John Bottomley, Treas.
J. ANDREW WHITE, Editor. WHEELER N. SOPER, Asst. Editor.
Volume 5 (New Series) November, 1917 No. 2

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WIRELESS AS AN AID TO COMMERCE DESTROYERS

WIRELESS has been employed so extensively in the operation of the German sea raiders that particular interest is attached to the news that two commerce destroyers are cruising about in the South Pacific. The submarine peril has been occupying the attention of most of us, but the notable exploits of the Emden and the Möewe have not been forgotten. The Emden, it has been suggested with good reason, was in constant communication by wireless with some one high in authority in Berlin who directed the activities of the cruiser. The Möewe had a scout ship which used wireless to locate vessels of the Allies and reported their positions by radio to the cruiser.

After the Möewe had performed some notable achievements there was considerable talk in Berlin about what Germany intended to do by means of sea rovers. It was said that their use precipitated fewer "diplomatic difficulties" than submarines.

It seems that the vessels now reported in the South Sea were taken and manned by the Seeadler which was heard of off Trinidad several months ago. The Seeadler was disguised as a neutral sailing ship when she set out from a German port. But after she had successfully eluded the patrol, the guns which were concealed in her hold, were mounted, a wireless apparatus was installed and she began to look about for victims, finding a considerable number of them, apparently among sailing ships. Of the manner in which she employed wireless on her cruise nothing has been said. It is reasonable to suppose, however, that the art proved as serviceable to the commander of the Seeadler as to the captains of the Emden and the Möewe.

The activities of the Seeadler passed out of notice for a time and it was believed that she had been captured or sent to the bottom. But it turns out that she was stranded and abandoned. Her guns were saved and perhaps her wireless apparatus too. At any rate, enough of her war equipment was transferred to the two ships she took to fit them out as commerce destroyers.

How much destruction they have accomplished has not come to light, but the Seeadler, in the early stage of her sea roving, had destroyed vessels amounting to more than 26,000 tons. The commander of the Möewe, after her second cruise in the Atlantic, reported the capture or destruction of twenty-seven vessels, with a total tonnage of more than 123,000 tons. In these cases wireless, contrary to the history of the art in the past, has been used as an agent of destruction rather than of salvation.

HOW AN AMERICAN STEAMSHIP WAS SAVED FROM A SUBMARINE

WHILE the brains of the Allied powers are being concentrated on a means to effectively combat the ravages of the U-boats, wireless continues to serve, in some instances, as the instrument of aid for prospective victims of the undersea craft. The art was called into service to advantage when an American steamer, a Luckenbach craft, which arrived at a French port on October 24, was attacked by a German submarine.

A lookout on the steamship sighted the enemy craft on the port bow soon after the vessel had entered the danger zone. Even before he had time to report the presence of the U-boat the latter fired a shot which barely missed its mark. The plight of those on the American steamship was desperate, for the submarine was in such a position that escape was practically impossible. So the captain ordered a wireless call for assistance sent out.

Meanwhile the gun crews of the submarine and the steamship began exchanging shots. The U-boat maintained an incessant fire and maneuvered at the same time to keep out of the range of the shots from the American vessel. Altering her course, the latter steamed ahead at full speed. But she could not get out of range of the submarine's guns and several shots took effect, putting her engines out of commission and placing her at the mercy of the under-sea craft. The U-boat steamed closer to the steamship, sending shot after shot at the vessel.

When the situation looked darkest for the steamship a low streak of black smoke was sighted in the distance. It came from the funnels of an American destroyer which had picked up the wireless call for aid and was speeding to the assistance of the distressed vessel. The destroyer headed directly for the U-boat which immediately submerged. It was not seen again.

The arrival of the American destroyer was unexpected by those on the steamship, although the former craft, while on her way to the rescue, had wirelessed encouragement in the form of such messages as "Hold on!" "Stick, we are coming!" "But the radio apparatus of the steamship had been disabled soon after the submarine began her attack and the messages were not received. However, the submarine was apparently aware of the destroyer's approach, for she took good care to disappear beneath the water before the destroyer got within range. So the wireless saved the day for the steamship.

CURTAILING THE ACTIVITIES OF GERMANY IN SOUTH AMERICA

THE Government of Argentina, it is declared in a dispatch from Buenos Ayres, has withdrawn permssion granted to a German wireless company to attempt to receive radio messages from the German station at Nauen. The German wireless service, consisting for the most part of messages from the semi-official Overseas News Agency, which were sent to the United States through the Sayville station before the entrance of this country into the war, is distributed from Nauen.

Since the United States declared war against Germany, it has been reported on several occasions that information was being sent to Germany from South America by means of wireless. It would seem that the revelations concerning the activities of Germany's agents are having practical effect.

THE RADIOPHONE FOG WARNING DEVICE

A STATEMENT from the office of the United States Naval Communication Service says that the attention of all ships navigating in the vicinity of Point Judith, near Newport, R. I., is invited to the recent installation at Point Judith Light of a radiophone fog warning device.

The apparatus will be of use to commanding officers in picking up the light in thick weather, as experience has shown that operators can judge to some extent the distance according to strength of signals with a known normal range. Although measurements have been taken to determine the limit of the range of this apparatus, too much reliance should not be placed in it until its worth has been proved under service conditions.

The apparatus will be in commission beginning about October 1, 1917, and will be in operation during fog, mist, rain and falling snow. The warning consists of the repeating of the words, "Point Judith Light," every five seconds, with limit of range of about eight miles. After every third repetition the warning, "you are getting closer; keep off," is sent out with a limit of range of about two miles.

The apparatus required for the reception of the warning signals is an ordinary radio receiver. Crystal detectors may be used. The wave-length is varied continuously between 550 and 650 meters.

It is requested that reports be forwarded to the lighthouse inspector, Tompkinsville, N. Y., concerning the range and value of this fog signal as found by experience under service conditions.

The system is yet in its first stages and it will doubtless be improved in the course of actual practice. The fact has been pointed out that before long every lighthouse will be shouting its name and other information so that the illumination will become of secondary importance.

FROM WASHINGTON TO HAWAII BY GOVERNMENT WIRELESS

THE opening of the United States Navy's high-power wireless station at Pearl Harbor, Hawaiian Islands, took place recently. Messages were exchanged between Washington and Pearl Harbor, a distance of approximately 5,000 miles. Reports of the tests indicate that communication between Washington and the Philippine Islands will be accomplished with the aid of one relay through the Pearl Harbor station.

The Pearl Harbor station is one of several high-power stations constructed by the United States Government.

COMMUNICATION OPENED BETWEEN JAVA AND CORREGIDOR ISLAND

THE Chief of the United States Signal Service recently announced the establishment of direct communication between the wireless station at Koeping, Java, and the army station at Corregidor Island at the entrance to Manila Bay. The Koeping station was opened on April 8 last, by the Colonial Governor of the Dutch East Indies.

A SUGGESTION FOR RELIEVING THE CONGESTED CABLES

THE congestion of cable facilities between the United States and Europe has brought forth the suggestion that the trans-Atlantic service, which was closed as a result of the war, be used. Secretary of War Baker, in explaining why permission to go to France could not be granted to any more newspaper correspondents, said that the American newspapermen now in that country were utilizing all the cable resources which it was possible to place at their disposal. Government messages, of course, receive first consideration and the frequent sending abroad of troops adds to the burden placed on the cable service. That the wireless should be employed as a means of conveying newspaper dispatches seems a not impractical idea.

A CALL FOR INSTRUCTORS IN WIRELESS AND BUZZER WORK

AT THE request of the United States Army, the Federal Board for Vocational Education has undertaken to aid the Army to secure the proper training of conscripted men as radio and buzzer operators (international or continental code) before they are called into service in the second and following drafts. A circular has been issued for the purpose of supplying information to school authorities who will undertake this work as a patriotic duty. In this circular is enumerated a list of those who may be admitted to classes. It follows:

Only conscripted men due for the second and following drafts should be admitted.

Only conscripted men should be admitted who have passed a physical examination and are certain to be called.

One of the chief purposes of the class should be to determine early what men are not fit to become successful operators, in order that they may be dropped at once.

Conscripted men from all occupations and professions who desire this training are to be admitted to the class if properly qualified. Most of these men will, of course, return to the practice of these occupations and professions at the close of the war. This training is for war service only.

For fear of a misunderstanding, it is again stated that these classes should not be open to anyone who is not due for service in the Army. This will exclude all such persons as: Girls and women, persons under military age, persons unconscripted, persons conscripted but unable to pass a physical examination, persons exempted for any cause, and persons who are seeking free training along commercial lines for service with railroads, telegraph companies and private concerns.

The Federal Board for Vocational Education has written to The Wireless Age asking its aid in supplying instructors in radio and buzzer work for schools throughout the country. Persons familiar with the international or continental code, should send their names, addresses and qualifications to The Wireless Age, which will forward them to the proper authorities. The basis of compensation will have been determined by the time this issue of The Wireless Age is off the press.

THE MEMBERS OF THE NEW CENSORSHIP BOARD

MEMBERS of the new Censorship Board authorized by the Trading with the Enemy act have been appointed by the Post Office Department and the Committee on Public Information. Its duties have to do with the censorship of wireless as well as other means of communication. Robert L. Maddox, Superintendent of Foreign Mails, was named as a member of the Board by the Postmaster General, and Edgard Sisson, head of the visé division of the Information Committee, by Chairman Creel. Mr. Sisson has had the advantage of having made a special study of European censorship methods. Major General McIntyre and Lieutenant Commander Belknap, representing respectively the War and Navy Departments, have also been appointed members of the Board. No other appointment remains to be made except that of a representative of the War Trade Board.

It is likely that the Board will continue, with few changes, the methods of censorships employed by the War and Navy departments. With the advantage of knowing the practices of the European censors, the American Board should make an excellent showing.

THE DEMAND FOR THE TECHNICALLY-TRAINED MAN

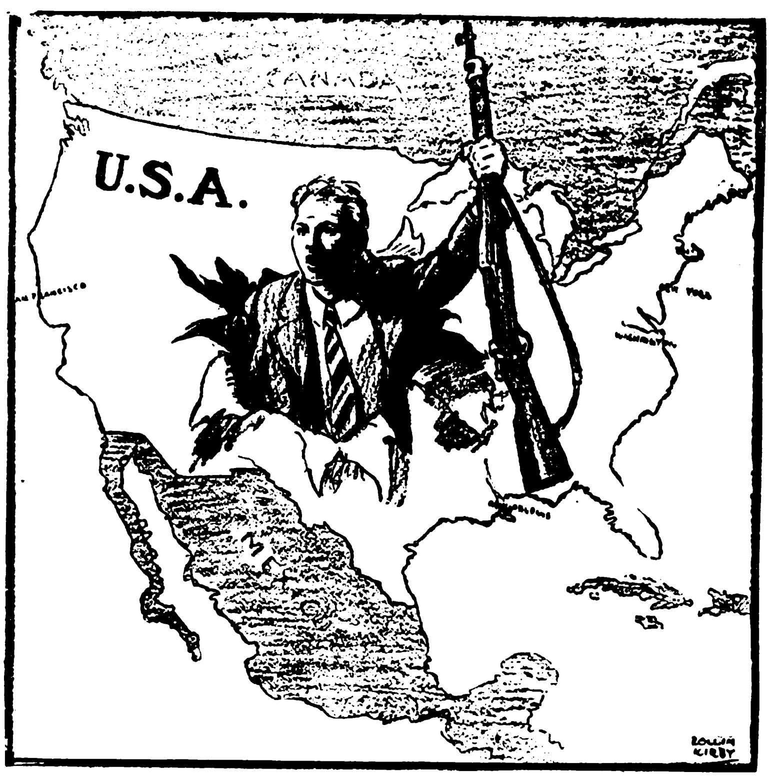
STUDENTS of wireless, whether they be amateurs or masters of the higher phases of the art, will find material for thought in the contents of a letter issued by the University of Illinois concerning the demand for men of engineering skill and training. It is pointed out that never in the history of this

country has there been so great a call for men having technical training in engineering as at present. The war in Europe has been a war of engineers and of the product of engineers, and every effort has been made by the European powers to conserve and increase the supply of men who are competent to carry on the work of the industries upon which its success depends.

That the Government is also alive to the situation is shown by a letter from P. P. Claxton, United States Commissioner of Education, to the heads of the various technical schools and colleges in this country. The letter, which was authorized by the Secretary of War, says that the successful prosecution of the war depends in large degree on the services of scientific and technical experts. It is of the utmost importance that the supply of men who have had advanced technical training should not be cut off more than is necessary.

In view of this fact, the War Department believes that students in technical schools and colleges who are within the age limits of the selective draft should be treated in the same manner as the workers in the industries which are devoted to the manufacture of war materials. Under this ruling, the presidents of colleges and technical schools may properly urge the district exemption boards to exempt students in their institutions who give promise of special aptitude for the technical and scientific professions until these students have finished their courses. It is expected that institutional officers will exercise due caution and will not claim exemption for students whose success in technical careers is open to doubt.

Attention is called to the fact that each case is to be considered by the district exemption boards on its own merits. Students in technical schools are not exempt as a class.



From the New York World

His Day!

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

ARTICLE II

THE MARINER'S COMPASS (continued)

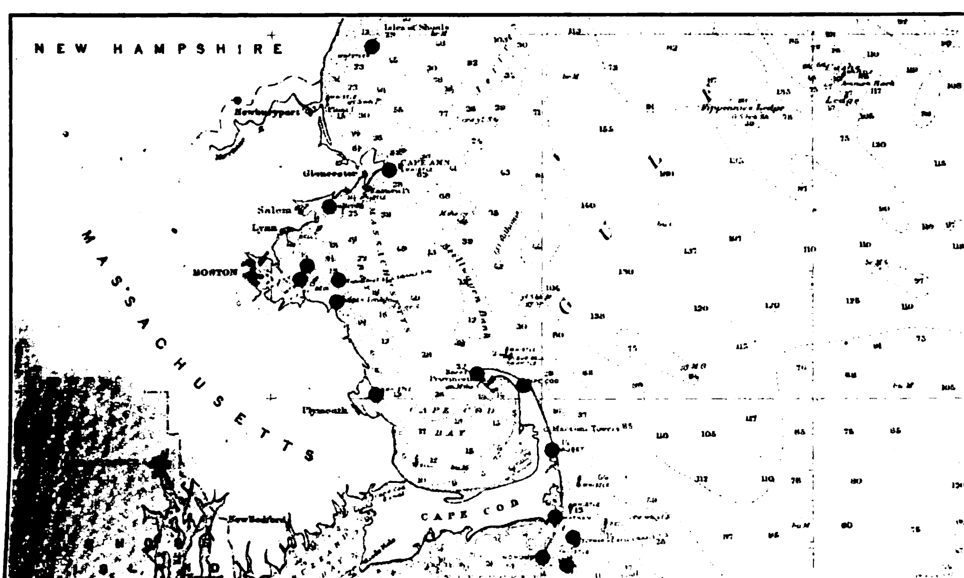
ON THE inner side of the compass bowl are marked two, or sometimes four, vertical lines called lubber lines. The compass should be placed so that a plane passing through two of these lines, opposite to one another, falls in with, or parallel to, the keel of the vessel. One lubber line always indicates the compass direction of the ship's head.

There are two types of magnetic compasses, the liquid or wet, and the dry type. In the wet type the compass card nearly floats in a liquid composed of alcohol and water; the weight is partly taken off the pivot, thus minimizing friction, and the compass works easier. The liquid has a tendency to decrease vibration of the card when the ship works its way through the water.

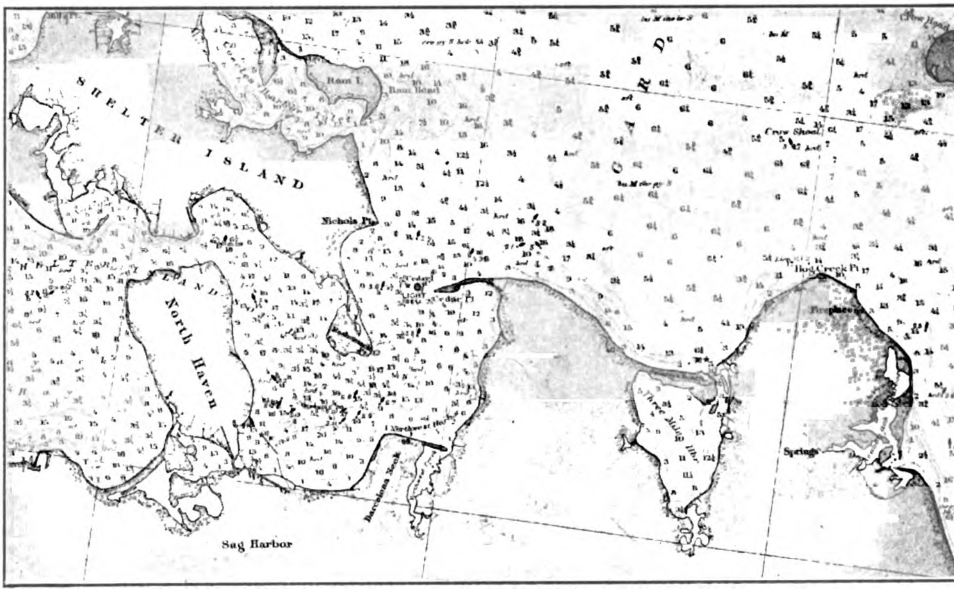
This type of compass is now generally in use as it has many advantages over the other type. The standard for the dry type compass is Sir William Thompson's (Lord Kelven) compass. It consists of a strong paper card with the central parts cut away to give it lightness; the outer edge is stiffened with an aluminum ring. The pivot is fitted with an iridium point on which rests a light metal boss fitted with a sapphire bearing. Silk cords are fastened to this boss by one end; the other end is fastened to the rim of the compass card and is in this way suspended. The cords are to some extent elastic and thus absorb some of the shocks due to motion of the ship. Eight small magnetic needles are suspended from the aluminum ring, keeping the center of gravity low.

THE MARINER'S, OR NAUTICAL CHART

A nautical chart is a map representing a miniature portion of the sea, lakes or navigable rivers with coast lines, depths of water, nature of bottom,



Mercator's chart

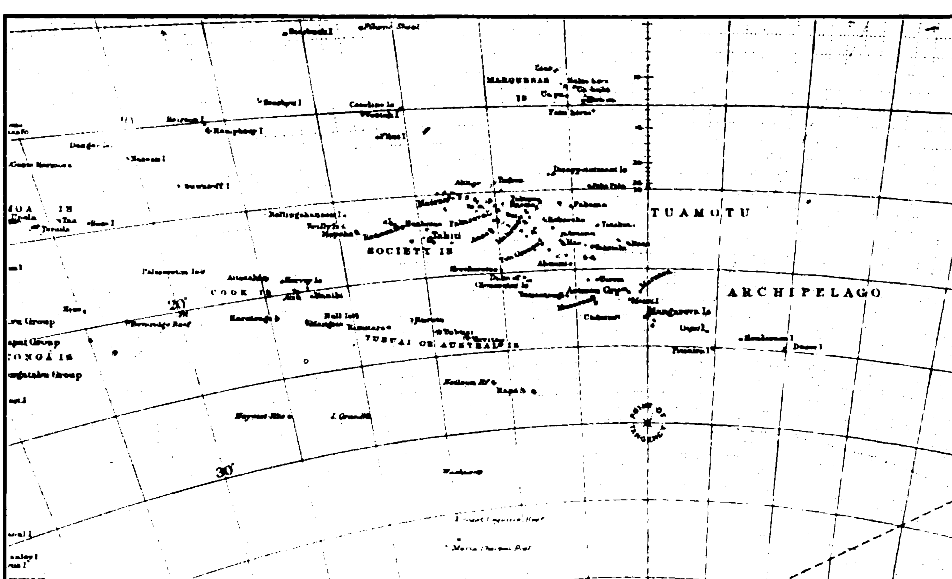


Polyconic chart

lights, lighthouses, buoys, currents and other useful information. There are three kinds of charts—Mercator's, polyconic and gnomonic projection chart.

On the **Mercator's chart** the meridians are made parallel to one another, and the distance between the parallels of latitude is lengthened, corresponding to the widening of the meridians. On this chart the earth is represented as a flat surface and the track of the vessel is shown as a straight line. This chart is used for coast and ocean navigation and is now being adopted for inland waters, bays, sounds and harbors in the United States.

The **Polyconic Chart.**—On a chart constructed on the polyconic principle,



Gnomonic projection chart.

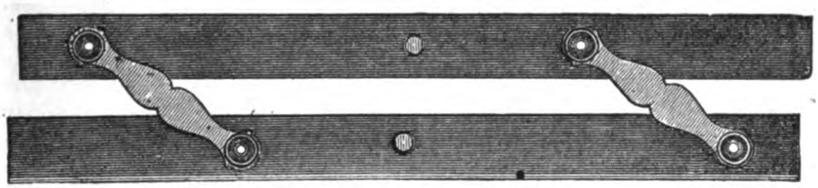
the meridians converge toward the poles and are in reality curved lines; the degrees of latitude and longitude are projected according to their true value. A straight line on this chart represents a near approach to a great circle, and cuts all the meridians at a slightly different angle. On account of the greater convenience of the Mercator's chart, however, this type of chart is not as much in use now as it was in former days.

The **Gnomonic Projection Chart.**—In a gnomonic chart, the straight line between any two points represents the arc of a great circle and is therefore the shortest line between those two points. This chart is used in the polar regions where a Mercator's chart cannot be constructed. It is also used for finding the course and distance in Great Circle Sailing.

The meridian of Greenwich is adopted as the first, or prime meridian, for charts constructed in the United States as well as in most of the countries of Europe and Japan.

PARALLEL RULERS

These rulers are used for drawing lines parallel to one another in any direction, and are chiefly used for transferring the course line (rhumb-line) on the chart to the nearest compass or diagram in order to ascertain the

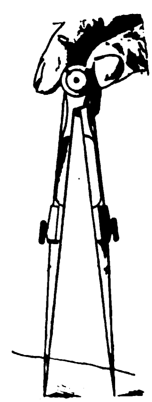


Parallel rulers

course or lay off course and bearings. They are generally made of hard wood, ebony or boxwood being preferred.

DIVIDERS OR COMPASSES

This instrument consists of a pair of metallic legs, movable about a point, and so arranged that they will open and may be set at any desired angle; the points are generally made of steel, but one point may be replaced by a pencil or pen. The instrument is called divider when used to measure distances and compass when used to draw circles or arcs.



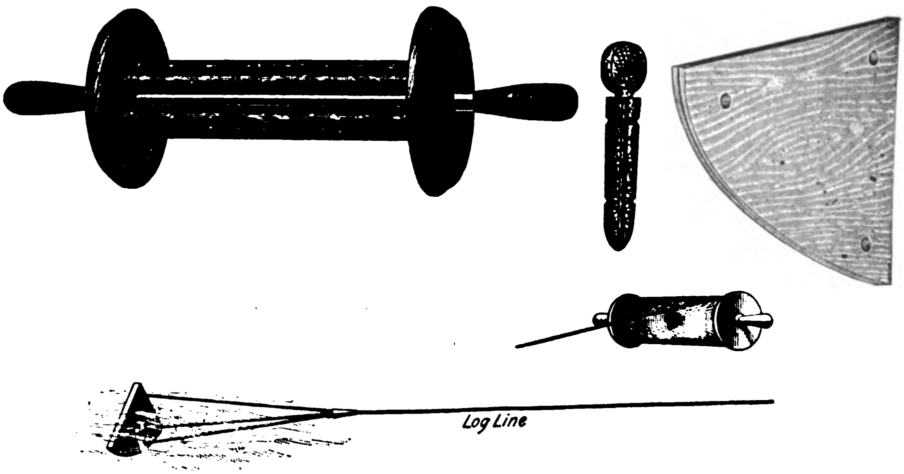
Dividers

LOG AND LOG-LINE

The chip log is used for measuring the speed of the vessel and consists of three parts, the log-chip, the log-line and log-glass. The log-chip is a triangular shaped piece of wood weighted with an insertion of lead at one edge in order to keep it upright as it floats in the water. The accompanying illustration shows clearly this part of the instrument.

The log-line is generally about 150 fathoms in length (depending on the speed of the vessel). One end is fastened to the log-chip the other end to the reel on which it is wound. About twenty fathoms from the log-chip end is fastened a piece of rag or bunting sufficiently large (about 6 or 7 inches long) so it may be felt even in a dark, cold night when gloves are used. The part of the line between the log-chip and the piece of rag or bunting is called stray line and allows the chip-log to get sufficiently far away from the disturbed water in the wake of the ship. The remainder of the line, when a twenty-eight second-glass is used, is divided into lengths of forty-seven feet, three inches, called knots; short pieces of marling or fish line are inserted

between the strands of the log-line at these intervals and marked one, two, three, four knots, etc., according to the numbers from the stray line-rag.



Log chip, toggle and log reel (United States Navy pattern)

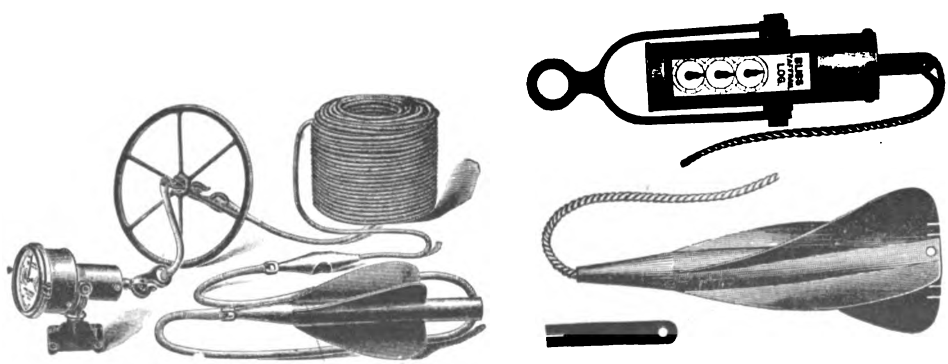
Each knot is further subdivided into four equal parts, marked by a piece of plain line without any knots. This indicates quarter knots; when a fourteen second-glass is used the indicated speed must be multiplied by two.

A nautical mile or knot is 6.080 feet and as the length between each knot on the log-line must be in the same proportion to a nautical mile as the number of seconds in the glass is to an hour, the following will be the formula for computing the length of a knot when a twenty-eight second-glass is used: One mile equals 6,080 feet; one hour equals 3,600 seconds, therefore:

$$3600:28=6080:X$$

$$X=\frac{28\times6080}{3600}=47 \text{ feet } 3.4 \text{ inches.}$$

The log-glass is a glass of the same shape or form as the old-fashioned hour glass. It is partly filled with sand; two glasses are used; one indicates twenty-eight seconds of time and the other fourteen seconds. The first is generally used when the speed of the vessel is about four to five knots; at higher speed the fourteen second glass should be used and the result mul-



Two types of patent logs

tiplied by two. Use your watch or chronometer to determine from time to time if the glasses are correct.

The **Ground-Log.**—In shallow water where the direction of the vessel is influenced by tides or currents, the log-chip may be detached and a lead attached to the end of the log-line; the lead is thrown overboard and the speed measured by the log-glass in the usual manner. The ship's course is opposite to the direction of the log-line; use your compass to ascertain this.

THE PATENT LOG

The patent log is a mechanical device to ascertain the speed of the ship. At one end is attached a rotator, and the other end is fastened to an indicator which shows the number of knots on the dial the ship has travelled Several different models are in the market.

THE LEAD

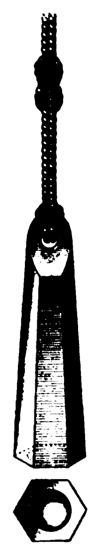
This contrivance consists of a line with a lead attached to one end. This is a valuable aid to the navigator, especially in foggy weather, or when out of sight of land. The hand lead weighs from seven to fourteen pounds; the deep sea lead from thirty to one hundred pounds. The line is from one hundred fathoms upwards in length.

The hand lead has nine marks and eleven deeps; the marks are as follows:

At two fathoms from the lead with two strips of leather.
At three fathoms from the lead with three strips of leather.
At five fathoms from the lead with a white rag.
At seven fathoms from the lead with a red rag.
At ten fathoms from the lead with leather with a hole in it.
At thirteen fathoms from the lead with a blue rag, or three strips of leather.
At fifteen fathoms from the lead with a white rag.
At seventeen fathoms from the lead with a red rag.
At twenty fathoms from the lead with two knots.

The deeps are unmarked fathoms. The deepsea lead is marked the same as the hand lead up to twenty fathoms, after which it is marked as follows:

At twenty-five fathoms with one knot.
At thirty fathoms with three knots.
At thirty-five fathoms with one knot.
At forty fathoms with four knots.
At forty-five fathoms with one knot.
At fifty fathoms with five knots.



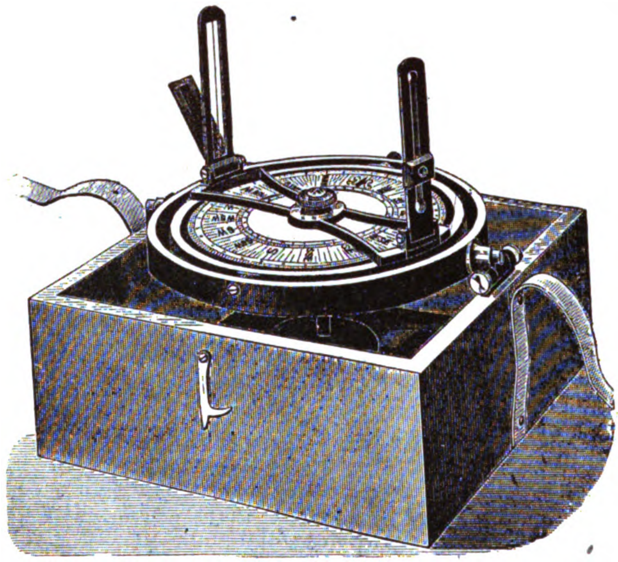
The lead

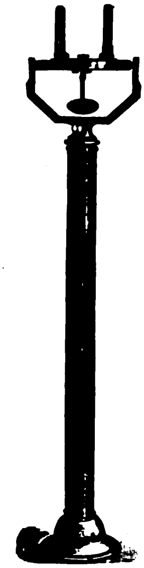
The markings of the line are continued so on up to one hundred fathoms or more.

Measure the lead line frequently while it is wet and re-adjust the markings whenever necessary. At the lower end of the deep sea lead is a hollow which should be filled (armed) with white lead or tallow in order to bring up samples of the bottom when using the lead.

SOUNDING MACHINES

There are several types of these machines in the market which are used instead of the deep sea lead, over which they have great advantage. Great depths may be measured quickly and accurately without stopping the ship.





The pelorus *Pelorus stand*

THE PELORUS

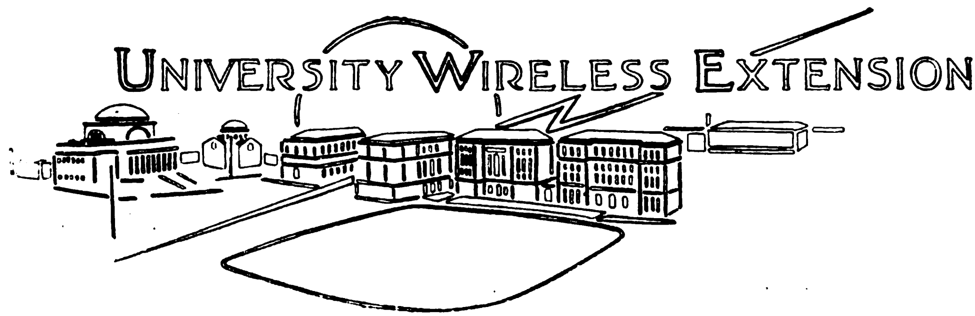
The pelorus, or dumb compass, consists of a circular disc revolving inside a metallic ring mounted in gimbals upon a standard which may be placed in any convenient part of the bridge or ship when a clear view all around the horizon may be obtained. This instrument is used for taking bearings of land objects, such as lighthouses, peaks, points, etc., as well as for observing amplitudes and azimuths of the heavenly bodies.

(To be continued)

THE WAR AND THE MERCHANT MARINE

One gratifying result of the war has been to show that there is no enfeebling of the American tradition of effectively handling great questions that concern the nation. The activities of the navy already indicate that it is prepared to keep up the standard which has been maintained in the past. Americans, as a rule, are fond of the sea and thousands of young men are finding now an opportunity of carrying out their ambitions to sail the ocean. In the ranks of the navy are many students from the Yale, Harvard and other seats of learning. It is not likely that the interest of these young men in the sea will cease with the ending of the war. Many will continue to follow the sea and consequently the strength of the American merchant marine will be strengthened.

America, it seems, has an excellent chance of swiftly developing her power on the sea. The country is building vessels under her own flag and, with the object of facilitating the work, sundry old ideas have been discarded and new ones substituted to advantage. The Shipping Board should have loyal support from every one in a position to give it in carrying out its plans.



Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE XI

CONTINUING our consideration of high current microphones for modulation in radio telephony, we come to a type of telephone relay used by Mr. W. Dubilier. The radiophone transmitter with which it is employed has been illustrated in Figures 34, 35 and 36. The inventor (in 1911) was well aware of the advantage of transferring speech from telephone lines to the radiophone transmitter and designed the relay for that purpose. A description thereof follows:

"Figure 127 shows a cross section of the relay. The complete transmitter consists of the magnets *A, A* wound with two-ohm winding *B, B*, and placed opposite to each other with the diaphragms and carbon containing cup between. (There had been adopted a type of transmitter with *two* diaphragms with the carbon between, both diaphragms swinging inward or outward in synchronism and thus producing greater changes in the resistance of the carbon between them than if one of them were fixed). The diaphragms are approximately 5 inches (12.7 cm.) in diameter and 0.036 inch (0.9 mm.) thick. The ebonite disc *D* is used to mount the diaphragms, and is drilled with large-sized holes so as to prevent "air packing" or talking against each other.

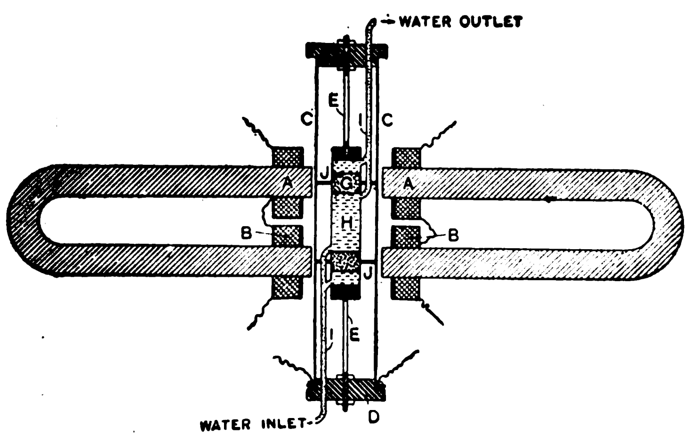


Figure 127—Cross section of Dubilier high current telephone relay

"A cross section of the carbon-containing cup is shown in Figure 128. It resembles three brass rings placed one within another, forming three independent containing portions. Water circulates through the chambers *F* and *H* by means of the inlet and outlet tubes *I*, and middle chamber *G* (of Figure 127) is used to retain the carbon granules. To make contact with the granular mass, circular rings of platinum, *J*, *J* are used, which are first soldered to the diaphragms *C*, *C*. The platinum rings are drilled with small holes round the entire circumference so as to allow a free circulation of air, and through one of these holes the small inlet and outlet tubes are run. The contact is made in the center of the granular mass. A mica disc is used to retain the granules in the chamber."

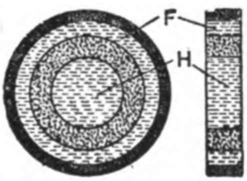


Figure 128—Cross section of carbon-containing cup of Dubilier high current relay

The transmitter in question was designed to carry currents up to 6 amperes. It seems to have been operative; since, as stated previously, radio telephony over 250 miles (400 km.) was accomplished with such apparatus.

In Figure 129 is shown in detail the high current microphone transmitter used by the Telephone Manufacturing Company (formerly J. Berliner) of Vienna. The entire radiophone set of which it is a part was illustrated in Figure 24. The microphone is seen to be mounted on a frame support with a ratchet clutch for holding it at any desired height. On the front of its case are the large mouthpiece and a double throw switch for "Calling" or "Speaking." Directly beneath the transmitter is placed a horizontal fan for cooling purposes.

In building high current transmitters, the granular carbon—carbon diaphragm type (e. g., as built by the Berliner Company) has been found to be suitable. The usual modifications made therein when used for the unusually large amounts of energy necessary in radio telephony are to replace the felt packing of the microphone chamber by asbestos packing or packing of some other uninflammable material, and to perforate the metal case so as to permit air cooling.

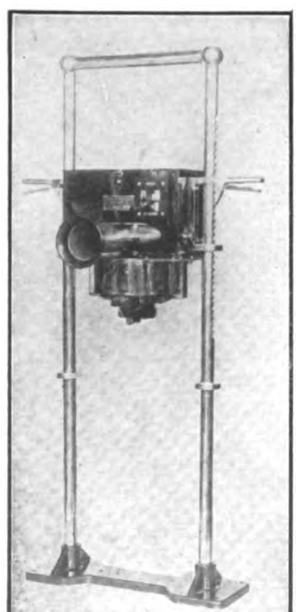


Figure 129—Heavy current Berliner microphone transmitter with fan cooling

One of the most remarkable and effective of high current microphones is that devised by Messrs. C. Egner and J. G. Holmström of Stockholm, Sweden. The inventors state that a normal microphone which, for a current of a few milliamperes has a resistance of say 200 ohms, at a current of 1 ampere has a resistance of only 5 to 8 ohms. The microphone is shown in plan in Figure 130 and in actual appearance in Figure 131. Corresponding parts are indicated by the same lettering. The whole device is provided with oil (or other fluid) cooling, by the attachment of the cooling reservoir *H* (of part *A* of Figure 131) to the back of the microphone chamber. Through this cooling chamber run the supporting and connecting rods from each of the microphones *A*. It will be noticed from Figure 130 and part *B* of Figure 131 that there are 16 of these microphones, which can be connected together in various ways, as indicated. The rods which run from the microphones through the cooling reservoir terminate on the connecting board *J* (part *C* of Figure 131). The cooling fluid is arranged to circulate in

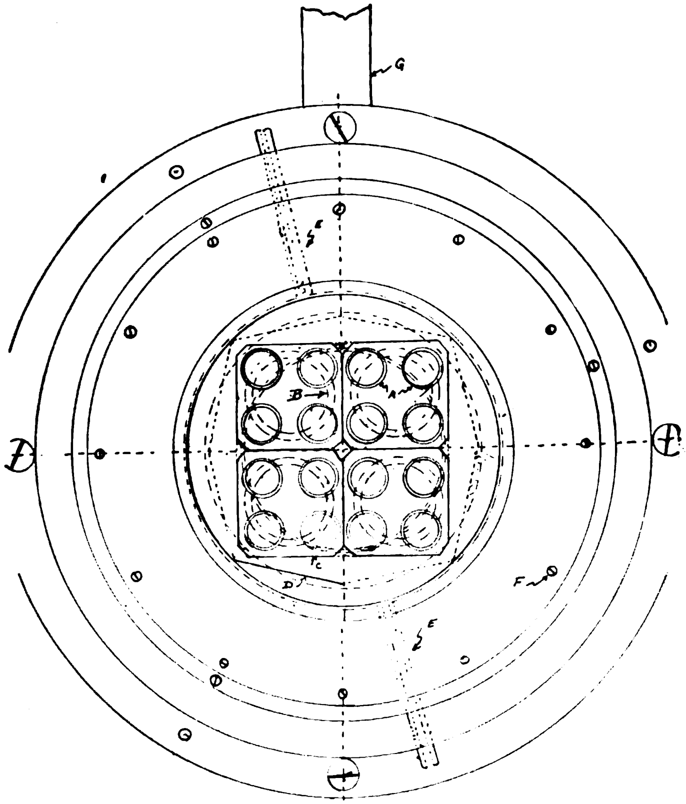


Figure 130—Front view of Egner-Holmström high current transmitter

a fashion similar to the "thermo-syphon" system sometimes used for gas engines, and heat is radiated from the flanges of the cooling chamber *H*. The cooling fluid must be an insulator.

The individual microphones are connected together permanently in 8 sets of 2 each, the 2 being always adjacent on the same row. The back of the microphone chamber is, in each case, a copper plate covered with thin carbon, and is fixed. From the copper plates pass the rods to the rear connecting board, previously mentioned. The vibrating electrodes *C* (of Figure 130 and part B of Figure 131) are 4 in number, each taking care of 4 of the microphones back of it. These microphones are insulated from each other by being supported on

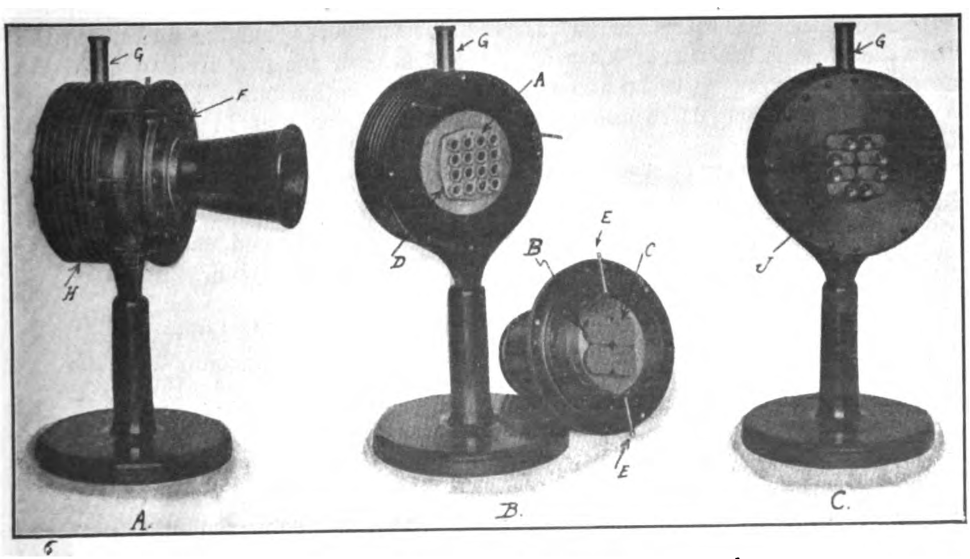


Figure 131—Egner-Holström high current microphone

cylinders of glass *B* (part *B* of Figure 131) which cylinders are in turn attached to the main vibrating diaphragm. The reason for the use of glass or a similar poor conductor of heat is that it is desired to prevent overheating of the main diaphragm since this has been found to lead to speech distortion. The individual microphone chambers are made up of rings of asbestos or a similar heat-resistant material, pressed by spiral springs against the electrodes *C* so as to close the microphone chambers.

The main diaphragm is a thin sheet (0.2 mm. or 0.008 inch) of aluminum or magnalium which is stretched as tightly as possible. The stretching is accomplished by tightening up, one after another, the screws *F* (Figure 130 and part *A* of Figure 131). Since the 4 vibrating electrodes *C* are attached rigidly to the central portion of the main diaphragm, they will vibrate in the same phase and amplitude. It is this fact which renders it possible to secure a stable arrangement of microphones in parallel in the Egner-Holmström transmitter.

In order to increase the internal resistance and resistance variations of the transmitter, hydrogen or some hydrogen-containing gas is passed through the microphone chamber by means of the inlet and outlet pipes *E*. Normally the gas supply required is practically nil after the air originally present in the microphone chamber has been displaced.

The various ways in which the individual microphones can be connected are shown in Figure 132. These are as follows:

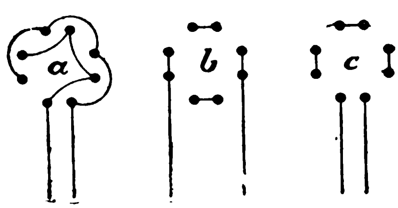


Figure 132—Connection arrangements of Egner-Holmström high current microphone

(a) 8 microphones in parallel, each of 2 in series. Proper applied voltage—10-15 volts. Proper current—up to 20 amperes.

(b) 4 microphones in parallel, each of 4 in series. Voltage—20-30 volts. Current—up to 10 amperes.

(c) 2 microphones in parallel, each of 8 in series. Voltage—40-60 volts. Current—up to 5 amperes.

It will be seen that the microphones can handle up to 200 to 300 watts (12 to 18 watts per individual microphone). The usual current (corresponding to case (b) above) is 10 amperes, but the makers of the transmitter, the Aktiebolaget Monofon of Stockholm, are prepared to build the transmitters to carry up to 16 amperes under these conditions. There are about 0.3 cubic centimeter (0.018 cubic inch) of carbon granules in each individual microphone.

Messrs. Egner and Holmström tried out their transmitter in connection with Professor Poulsen's apparatus shown in Figure 16. On June 29th and 30th, 1909, as previously stated, clear communication was achieved using this transmitter with 6 amperes in the antenna between Lyngby and Esbjerg, a distance of 170 miles (270 km.).

Another form of microphone transmitter of considerable interest was used by Mr. R. Goldschmidt of Laeken (near Brussels) in conjunction with the apparatus shown in Figure 60. The device in question is the invention of Mr. J. B. Marzi of Cornigliano (Liguria, Italy). The basis thereof is an attempt to prevent burning of carbon grains when heavy currents are used by the expedient of using a *moving stream* of carbon grains. Very finely powdered carbon will flow in practically the same manner as a liquid stream, and a portion of the carbon stream, passing between two electrodes, is used in this case as the microphone. The actual apparatus is shown in Figure 133, and the cross sections of

several forms thereof and the mode of connection are given by Figure 134.* Referring to parts I, II, and III of the latter figure a reservoir, 5, is filled with finely powdered carbon and from this reservoir a fine stream of carbon flows through the hollow pipe 6 till it is compelled to pass between the platinum surfaces 9. These may be portions of concentric spheres (as in part I), or an obliquely cut cylinder and a plane surface (as in part II), or portions of two coaxial cones (as in part III). In any case the carbons stream between these surfaces, which are the terminal electrodes of the high current microphone. The upper one of these surfaces is usually fixed whereas the lower one is movable, either by the voice directly or, as shown in part I, by means of an armature 2 controlled by the electromagnets 1, 1. The current for these electromagnets is derived from the circuit of an ordinary telephone transmitter, or from a telephone line. It is this feature which makes the device a relay. In Figure 133 the

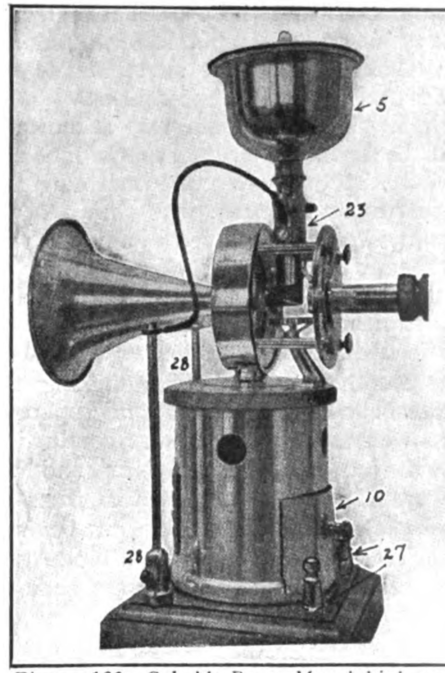


Figure 133—Scheidt-Boon Marzi high current microphone transmitter (relay type)

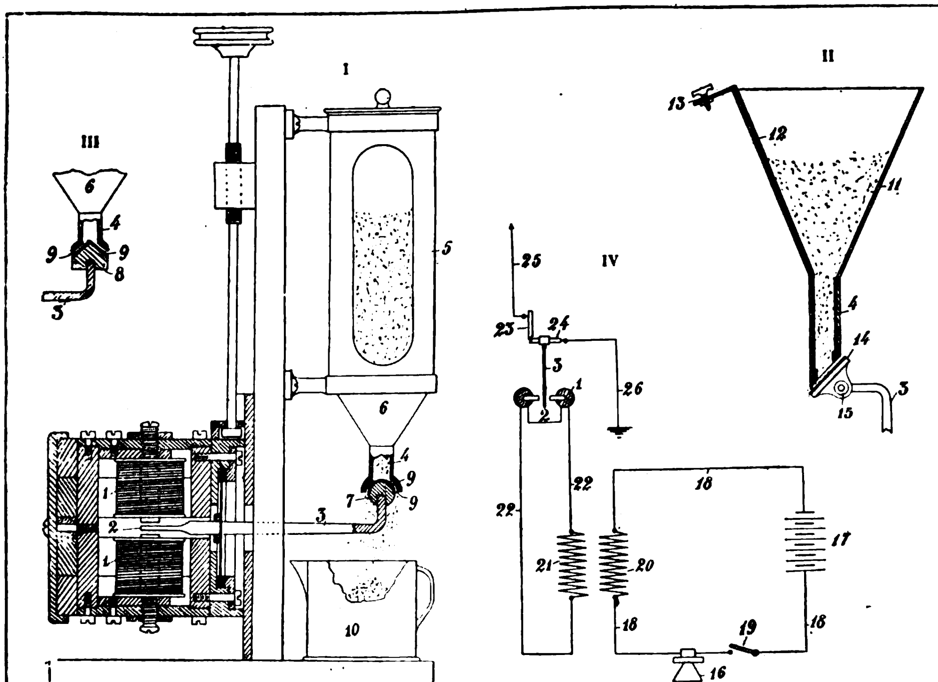


Figure 134—Details of Marzi high current microphones and relays

* Figures 133 and 134 are reproduced by permission from the French journa "T.S.F." and based on material from Mr. Scheidt-Boon of Brussels (1914).

terminals 27 are those of the electromagnets 1, 1 and the terminals 28 are the heavy current microphone terminals.

After passing the surfaces 9, 9, the carbon stream flows into the cup 10. At regular intervals, the contents of this cup should be emptied back into reservoir 5. The circuit diagram is indicated clearly in part IV of Figure 134. As will be seen, the ordinary microphone circuit is coupled through the induction coil 20, 21 to the circuit containing the electromagnets 1, 1 of the relay. The high current transmitter is shown placed directly in the antenna, though it can equally well be employed in any of the ways shown under ordinary "Microphone Transmitter Control". The weight of the entire apparatus is only about 9 pounds (4 kg.) and height thereof 18 inches (45 cm.) As previously stated, this transmitter, carrying 3 amperes, permitted communication from Laeken to Paris, a distance of 200 miles (320 km.)

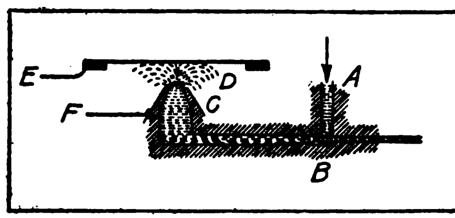


Figure 135—*Essential parts of Chambers liquid microphone*

Another method of attacking the problem of high current microphones has been the attempt to use conducting liquid jets of one type or another. Figure 135 shows the essential parts of a simple microphone of this sort devised by Mr. F. J. Chambers in 1910. At *A* a stream of electrolyte under a head of about 3 feet (1 m.) flows past the needle valve *B*. Here the flow is adjusted to a suitable amount. The liquid then passes through the conducting nozzle *C*, which is connected to *F*, one of the terminals of the microphone. After leaving the nozzle, the liquid stream impinges on the diaphragm *D* which is vibrated by the voice. The diaphragm is suitably connected to *E*, the other terminal of the microphone. It will be seen that the up-and-down motion of the diaphragm will alter the length and cross sectional area of the jet and consequently its resistance. It is found that such a microphone, because of the mechanical damping of the diaphragm by the jet, gives clear articulation without rasping side tone. The distance of the diaphragm from the nozzle is adjustable. The capacity of such a microphone is limited simply by the necessity of preventing the current-carrying electrolyte from boiling. In practice, Mr. Chambers found that about 400 watts could be handled by such a microphone.

Another type of liquid microphone, somewhat similar to that of Mr. Chambers, has been devised by Professor Giuseppi Vanni of Rome. The appa-

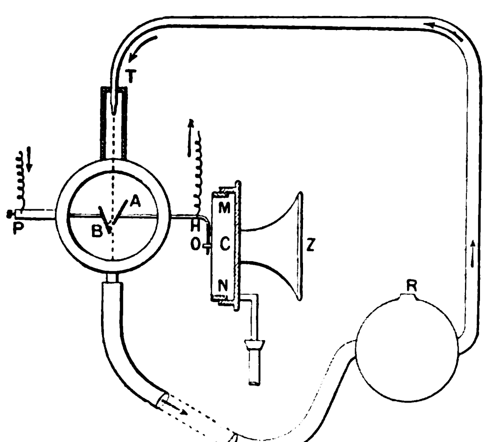


Figure 136—*Vanni's liquid microphone*

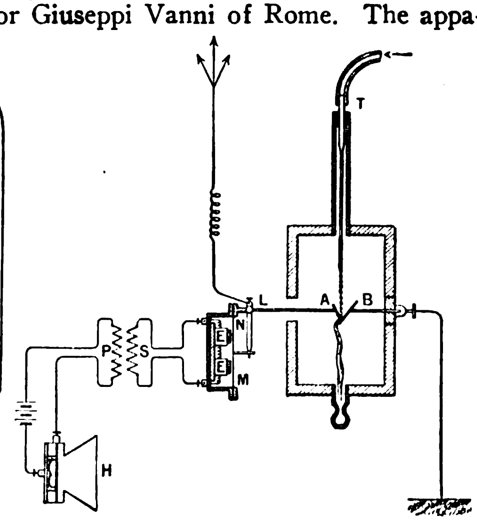


Figure 137—*Vanni's liquid microphone relay*

ratus is shown in Figure 136. A centrifugal pump *R*, made entirely of acid-resistant materials and operated by a small motor, forces a jet of dilute acid out of the ebonite nozzle *T*. The jet then falls on the inclined surface *A*, is deflected to the oppositely inclined surface *B*, is again deflected, and then passes back to the pump to resume its circulation. The pump pressure corresponds to 12 or 15 feet (3 or 4 m.) of water column. The terminals of the microphone, *H* and *P*, are connected mechanically to the electrodes *A* and *B*. *B* is fixed, but *A* is vibrated back and forth in an oblique direction practically perpendicular to the deflected jet. *Z* is the mouthpiece of the microphone, the diaphragm being connected at *O* to the mechanical control of *A*. The motions of *A* not only change the cross section of the jet from a cylinder to a flattened sheet, but also obstruct the stream more or less by the greater or less immersion therein of *A*. The electrode *A* therefore acts as a sort of shutter.

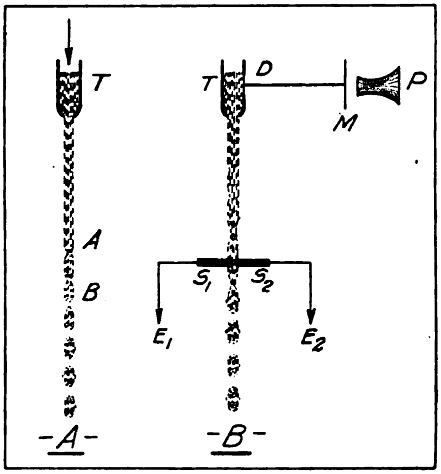


Figure 138—Essential parts of Majorana's liquid microphone

The Vanni microphone has also been arranged as a relay in the fashion illustrated in Figure 137. The usual transmitter *H* supplies fluctuating currents to the electromagnets *E*, which in turn control the liquid microphone by means of the iron diaphragm *NM*. This device was used in the experiments of Professor Vanni previously described, where it successfully controlled 1 kilowatt permitting radio telephony 625 miles (1,000 km.). The arrangement of circuits employed is given in Figure 59 in a previous article of this series.

Another principle which can be applied in liquid microphones is that of the instability of liquid jets, as first discovered by Chichester Bell in 1886. The phenomenon, which is based on the surface tension of the liquid, is illustrated in Figure 138, part *A*. This shows a jet of liquid escaping from a small tube, *T*. The orifice of the tube is supposed to be smooth and circular. The jet will proceed as a cylinder for a certain distance, and then a slight constriction will occur at the point *A*. Directly below *A* the stream will bulge, and then constrict still more below the bulge. At *B* the stream will break up into drops which, as they fall, will vibrate from oblate to prolate ellipsoids, passing through the spherical shape. We are not, however, concerned with the stream after it has broken up, but rather with its cross section at the bulge just above the breaking-up point. For it is found, by experiment, that the transmission of the least mechanical disturbance to the falling jet will move the breaking-up point up the stream toward the orifice, and the motion will be quite considerable even for very slight mechanical disturbances.

These facts have been utilized by Professor Q. Majorana of Rome in his hydraulic microphone, devised in 1906. Its essential parts are shown in part *B* of Figure 138. The tube *T* of glass or other insulator has a portion of its wall at *D* replaced by an elastic diaphragm which is attached to the larger voice-actuated diaphragm *M* by mechanical means. Placed in the jet just above the breaking-up point are the two electrodes S_1 and S_2 which form the terminals of the microphone. It is clear that the variations of cross sections of the jet at S_1S_2 will cause the necessary resistance variations. One unfortunate drawback with this form of liquid microphone is the excessive length of the jet (5 to 15 feet, or 2 to 5 m.) and its very great sensitiveness to slight shocks. As previously

described, Professor Majorana succeeded in telephoning 270 miles (420 km.) with such a microphone control. It has been stated that the device can control 10 amperes at a terminal potential difference of 50 volts, corresponding therefore to 500 watts.

(g) **VACUUM TUBE CONTROL SYSTEMS.** As has been previously described in considerable detail, a ready means of generating moderate, and even high outputs at sustained radio frequencies is by the use of the various types of hot cathode vacuum tubes. These tubes depend for their operation as oscillators on the potential of small conducting members such as the grid in audions, oscillions, and pliotrons. Since the amount of energy required to change the potential of small-capacity conducting members is itself minute, it would seem *a priori* that one of the most ready means of modulating the output of such oscillators would be by altering the potential of the member in question in accordance with the voice vibrations. As a matter of fact, the proper control of the oscillations generated in such a tube is not a perfectly simple matter, for reasons which will appear.

There are at least two available methods of controlling the output of vacuum tube oscillators, and instances of each of these in practice will be described. The first of these is by variation of the grid potential, the assumption being that as the grid potential becomes increasingly negative, the current through the tube (and therefore the available radio frequency output) continuously and proportionately diminishes. Difficulties of stability of operation, however, arise and the conclusion must be somewhat modified. The second of these methods is by varying the plate potential, the assumption in this case being that as the plate potential becomes increasingly positive, the current through the tube (and therefore the available radio frequency output) continuously and proportionately increases. This conclusion also requires some modification because of temperature and space charge limitation of plate current and because of the limits of available energy which must thus be introduced into the plate circuit. (See under "Sus-

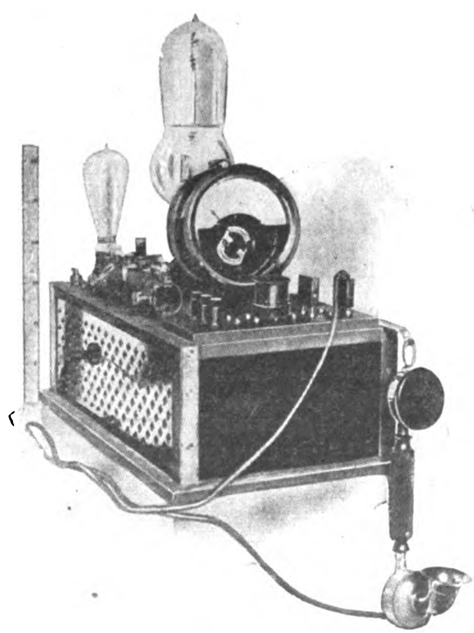


Figure 139—*Telefunken Company-Meissner radiophone transmitter,* 1913

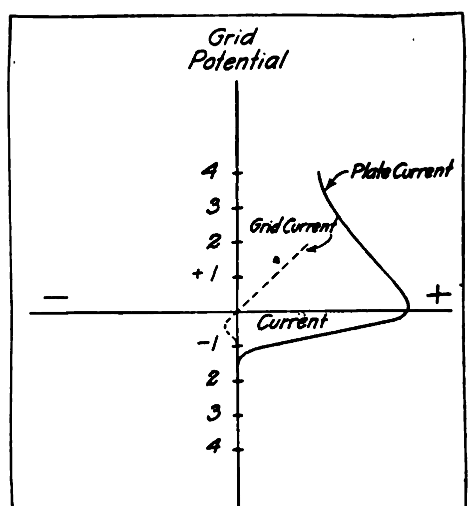


Figure 140—*Plate-to-filament and grid-to-filament characteristics of three electrode hot cathode tube containing gas*

tained Wave Generator," part (c), "Vacuum Tube Oscillators"; and specifically the descriptions given of Figures 61, 62, and 63 in a previous article of this series.)

There are a number of differences between the operation of the two systems of modulation mentioned, such as the relation between the modulated radio frequency energy and the necessary controlling audio frequency energy; but these differences will best be brought out in considering the actual systems in use.

Dr. Alexander Meissner of the Telefunken Company, working with the tube shown in Figure 73, and the circuit shown in Figure 71 for producing the oscillations, succeeded in carrying out some interesting experiments in radiophone transmission. He states that using a plate circuit voltage of 440, it was possible to obtain a radio frequency output of 12 watts in the antenna. This corresponded to an antenna current of 1.3 amperes with an antenna resistance of 7 ohms at a wave-length of 600 meters. No statement was made as to the mode of control, though for such small powers it is probable that a heavy current microphone would suffice if placed directly in the antenna or in a suitably associated circuit as indicated under the description of Figure 119.

The radiophone equipment used by Dr. Meissner in June, 1913, for transmission between Berlin and Nauen, a distance of 23 miles (36 km.), is shown in Figure 139. The von Lieben-Reisz bulb is mounted at the rear of the apparatus box.

While these experiments were significant, it must be noted that Mr. H. J. Round states that when the Lieben-Reisz tubes were used at such outputs, they lasted only 10 minutes because of disintegration of the filament by the positive ionic bombardment! This would naturally render their use under such conditions impracticable commercially.

We consider next the radiophone experiments carried out by Mr. Round of the Marconi Company. To begin with, we shall give the grid potential-plate current curves found for his tubes by Mr. Round. One of these is shown in Figure 140. It should be carefully compared with that shown in Figure 66 for the care of pure electron discharge tubes. Mr. Round's description of Figure 140 (with some added comments and slight alterations) will be given: "Suppose the plate to be made so positive that the whole tube would be glowing (i. e., filled with blue glow of the usual ionised gas discharge) except for the presence of the grid. Then, starting with the grid strongly negative, notwithstanding the plate being highly positive, the electrons cannot get through the grid because the grid is nearest to them. At a very small negative value of the grid potential, a few electrons can get through the grid and will fall to the plate and the number that will get through will rapidly increase until the grid is at zero potential; the current to the plate then having the value it would if the grid were absent. Afterwards, as the grid becomes positive, the current will decrease because the grid will absorb some electrons."

The detailed wiring of a Marconi Company radiophone transmitter (the receiving set of which will be shown under "Receiving Sets") is given in Figure 141. It will be seen that oscillations are produced by coupling the grid circuit $L'C$ with the plate circuit $L''C'$ by means of the inductive coupling $L' L''$. The grid circuit also contains the 30 volt battery B' and the 3,500 ohm resistance R', which latter is shunted by a suitable by-pass condenser permitting the transfer of radio frequency currents but preventing excessive direct grid current. Similarly, the plate circuit also contains the resistance R_1, R_2, R_3, each of which is 500 ohms and the resistance R_4 of 10,000 ohms. These prevent excessive plate current, "blue glow," and tube breakdown. In series with these is the plate battery B of 500 volts. The aggregate of resistances and battery is shunted by the capacity C' of the plate oscillating circuit. The radio frequency

energy thus produced is transferred to the antenna circuit at L_1 by an inductive coupling. The presence of oscillations in the antenna is indicated by glowing of the test lamp *TL* which can be short-circuited when not in use. The microphone *M* is directly inserted in the antenna circuit, and can also be short-circuited for purposes of tuning. The battery *B″* used for lighting the filament is an ordinary 80 ampere-hour storage battery. The battery *B′* for providing 500 volts consists of four cases of dry cells. These were found suitable for the needs of the occasion since only 10 to 20 milliamperes (0.010 to 0.020 ampere) were required. Thus the input is from 5 to 10 watts. The set is arranged so that it can also be used for telegraphy by manipulating the key *K* in the grid circuit. The change-over switch from sending to receiving is simple and is so arranged that it can be controlled from a distance thus permitting handling the set from any part of a ship, e. g., the chart room. Needless to say, the duplicate transmitter (microphone) and receiver could also be placed there. The set delivers 0.6 amperes in the antenna, and is guaranteed for communication over 30 miles (50 km.) with ship antennas 100 feet (30 meters) high and 200 feet (60 meters) apart. The set can, however, be pushed to give 1 ampere in the

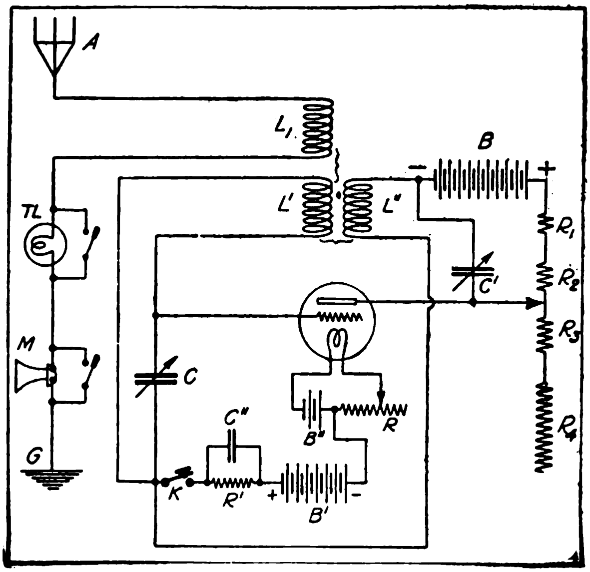


Figure 141—*Marconi Company radiophone transmitter*

Figure 142—*Marconi Company radiophone set*

antenna with an estimated sea range of 100 miles (160 km.). As a matter of fact, communication was established with such a set between Aldene, New Jersey, at the station of the Marconi Company and a station in Philadelphia, Pennsylvania, a distance of 65 miles overland (105 km.). The Aldene antenna was supported on two 200-foot (60 m.) towers 450 feet (145 m.) apart. The actual appearance of the set is given by Figure 142. The large generating valve is shown at *V* between the vertical supports. To its right is placed the small receiving valve.

It is stated by Mr. Round that the telegraphic range of these sets is twice the radiophonic range. The tuning is found to be unusually sharp, in fact, almost uncomfortably so. It was also found somewhat difficult to start these tubes rapidly in cold weather. Just before the war, work was proceeding with such equipment in the direction of a selective call system, but this had to be suspended.

Using tubes of the sort described, Mr. Round succeeded in getting 3 amperes in the antenna, which would probably correspond to about 50 watts output. The input was about 0.100 ampere at 2,000 volts or 200 watts, thus giving an

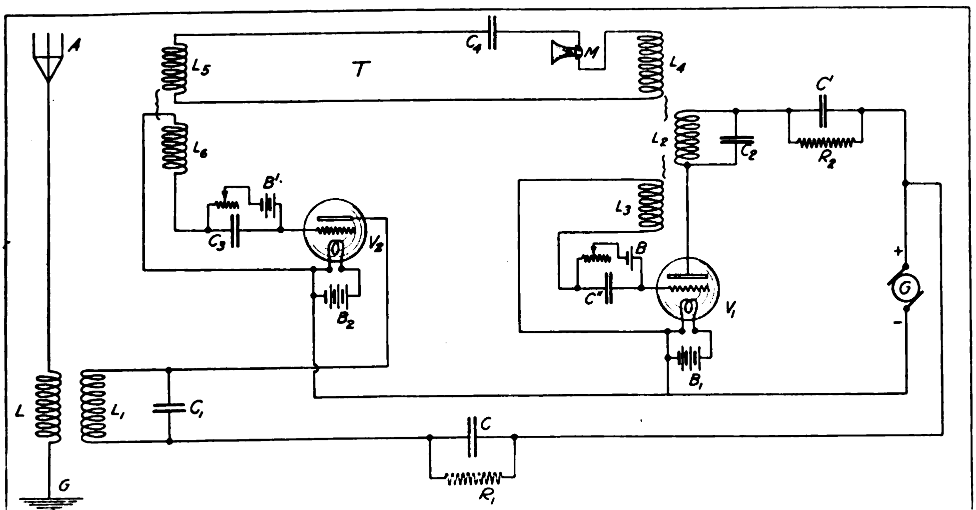


Figure 143—*Marconi Company-Round radiophone transmitter of* 1914

efficiency of about 25 per cent. The efficiency here referred to is the so-called "electron efficiency;" that is, it does not include in the input the energy required for lighting the filament, but considers only the plate circuit input and the radio frequency output. Mr. Round considers 2,000 volts to be excessively high for tubes of this sort, and states that experiments are being conducted whereby it is hoped to make the tubes available for use at lower voltages. The serious objection to lower voltages is that the high supply currents then required for appreciable outputs produce very rapid filament disintegration if gas be present.

Another form of the Marconi Company's radiophone transmitter is shown in Figure 143. Here a master oscillator V_1, is used, the output of which passes through an intermediate circuit *T* to the grid circuit of an amplifier, V_2. The output of amplifier V_2 is transferred to the antenna through an inductive coupling. The modulation control in this system is accomplished by placing a microphone in the intermediate circuit, thus varying the radio frequency voltage impressed on the amplifier grid. This system of master oscillator and amplifier is of considerable interest and the illustration shows one of the earliest forms thereof. The details of the master oscillator, V_1 are seen to be those of Figure

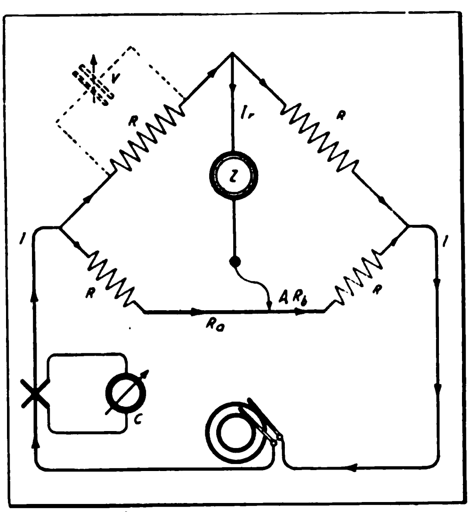
141. The amplifier V_2 is very similar except that its grid and plate circuits are not coupled. It will be noted that both the master oscillator and the amplifier are fed from the same plate generator G. Here we have a case where the microphone does not have to handle the whole of the antenna energy, and indeed the amount handled by the microphone M is roughly the antenna energy divided by the amplification produced in V_2. A modification of this system omits the amplifier but uses the microphone as part of the coupling between L_2 and L_3 in the master oscillator, thus suitably varying its output.

This is the eleventh article of a series on "Radio Telephony," by Dr. Goldsmith. In Article XII, which will be published in the December issue, oscillion radiophone transmitters are considered. The apparatus used is described and an account of long distance experiments is given.

MEASUREMENT OF THE AUDIBILITY CURRENT OF A TELEPHONE RECEIVER

A MEASUREMENT which has been the subject of much discussion among radio engineers is that of the strength of the least value of current required to produce a sound in the telephone which can just be recognized. The value of such a measurement is widely recognized, but owing to the complicated factors involved it has not been found convenient to carry out the complete set of measurements giving results adaptable to all circumstances.

At a meeting of the American Physical Society, E. W. Washburn presented a paper on a method for determining the audibility current, which is somewhat unusual. As shown in the accompanying drawing, a Wheatstone bridge is employed, having the resistance R, R, and R-1, R-1. These are noninductive and are constructed to have no self-capacity. A resistance wire, R_a, is fitted with a sliding contact and a scale, and is stretched between the ends of R-1 as shown. The sliding contact is inserted between the resistance coils, R, R, with the telephone receiver, Z, connected in series.



To ensure a balance of reactances, either of the resistances of the bridge arms may be shunted by a small variable air condenser, V. The arms of the bridge are supplied with current from a high-frequency alternator, H F, in series with which is placed the thermo couple, D, with the milli-voltmeter, C.

The resistance of that part of the slide wire which lies between the central position and the position occupied by the sliding contact when the audibility current, I_r, is passing through the telephone, is designated by ΔR_b. The strength of the current flowing through the bridge is determined by the thermo couple and milli-voltmeter previously mentioned.

The complete measurement is accomplished by adjusting the strength of the current, I, from the alternator, H F, until the range of silence on the sliding wire contact is found to have a measurable value. The range of silence is therefore equal to $2\Delta R_b$ ohms. It is obvious that the value of I_r can be obtained from the ordinary equation of the Wheatstone bridge.

Radio Science

HETERODYNE AMPLIFICATION BY THE ELECTRIC RELAY

THE amount of amplification to be expected by the use of the heterodyne receiver has been the subject of much discussion. In fact, investigators heretofore have found it difficult to account for the large degree of magnification thus obtained, and in some instances have drawn conclusions based on unwarranted assumptions.

In the earlier types of heterodyne receivers in which radio frequency oscillations were generated locally by an arc and the signals detected by a crystal rectifier, it was assumed by Messrs. Cohan and Hogan (who contributed largely to the development of the system in its earlier stages) that the complete process amplified the antenna or incoming signal energy, the detector being employed merely to rectify the local current. It has been shown also by Benjamin Liebowitz that theoretically the maximum amplification that should be obtained by the heterodyne system is four. However, owing to the remarkable amplification obtained by the perfection of the regenerative electron relay as a self-heterodyne by Armstrong, he was induced to make a deeper investigation of the subject.

In the "Proceedings of the Institute of Radio Engineers" for April, 1917, a method for determining the relative sensitiveness of the various methods of heterodyne amplification is described in detail by Armstrong, the complete circuits and general procedure being shown. It was not only determined that Liebowitz' conclusions in the main are correct for the simple heterodyne receiver, but that the amplifications to be expected from the regenerative electron relay are astonishing in the extreme.

In the self-heterodyne circuits of the regenerative type, where the combined functions of detection, amplification, and generation of a local source of radio frequency oscillations are accomplished in a single bulb, there are two methods of amplification which occur simultaneously in the same circuit, each one operating its own particular way, practically independent of the presence of the other. On account of the involved nature of the various phenomena, the problem of measuring the total amplification and separating the values into their component parts by direct measurement is not simple, hence an indirect method had to be employed.

Up to the time of the researches made by Armstrong, there was no reason to believe, in the light of present knowledge, that the magnitude of the self-heterodyne amplification would in any way differ from that obtained in an ordinary circuit with an external heterodyne, but practical results apparently indicated a disproportionality which had not been explained.

The problem was attacked by first measuring the amplification produced in a simple vacuum valve circuit and then measuring the total amplification produced when the same tube is provided with a regenerative circuit and used as a self-heterodyne.

The complete circuits for carrying out the investigation are shown in Figure 1 where the closed oscillation circuit of a receiving system is represented at N, an artificial antenna circuit at *M*, and two sources of radio frequency oscillations at X and Y. The oscillations generated by X were employed as a substitute for the incoming signaling energy at a given receiving station, and those generated by Y, as a source of oscillations for the heterodyne effect. The relative amplitude of the current flowing in the receiving circuit and that produced in the local

circuit of the vacuum valve were measured by the galvanometer, G-1, with the detector, D-1, and the galvanometer, G-2, with the detector, D-2, respectively.

In order to separate the various components of the plate current from its continuous component, a telephone transformer, T, was inserted as shown. Other precautions were taken to separate the audio from the radio frequencies. The reading of the galvanometer, G-1, was also shown to be proportional to the square of the radio frequency current in the circuit, *N,* and the reading of the galvanometer, G-2, proportional to the square of the audio frequency component in the plate circuit. Since the alternating current energy available for producing sound is proportional to the square of the current, the reading of the galvanometer, G-2, may be taken as a direct measure of the telephone signal strength.

To determine the amplification due to the heterodyne method during continuous wave reception, a difficulty was encountered in that there was no audible signal during the absence of the locally generated radio frequency current, and

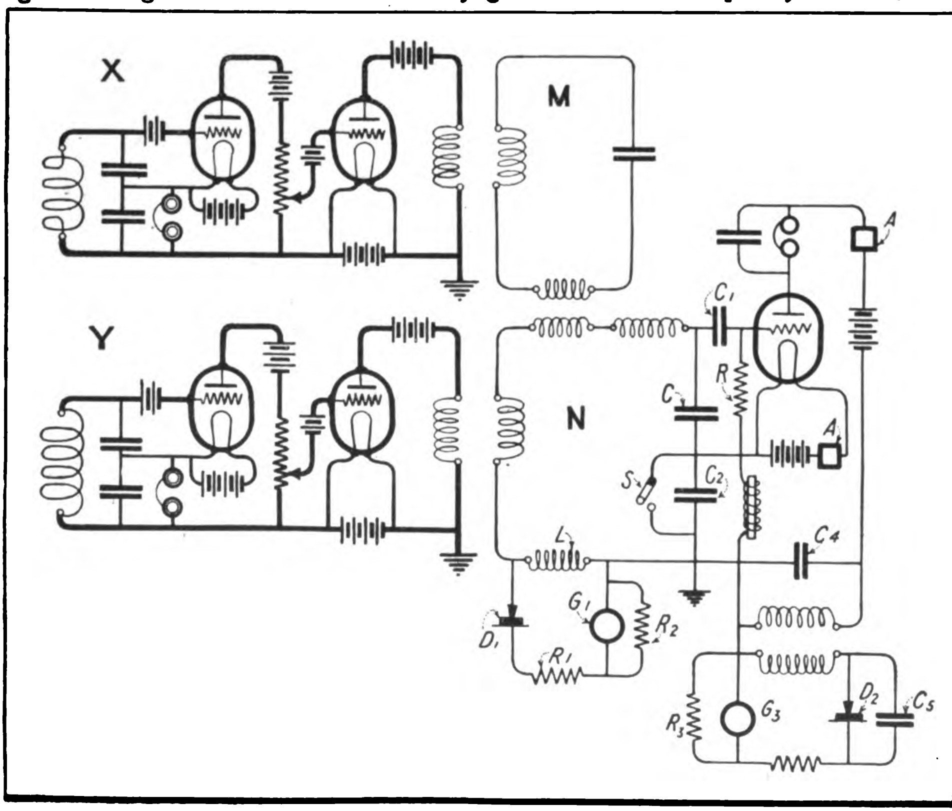


Figure 1

in order to obtain an audio frequency tone, a chopper had to be inserted in some part of the receiving system.

The first series of measurements were made for the purpose of comparing the signal strength obtained with the chopper and that given by the heterodyne when the local current was equal in amplitude to the signaling current. A special notation was given to this method of signaling namely, *the equal heterodyne,* that is, the incoming signal and the locally generated radio frequency current were equal in amplitude. The exact process of adjustment was described in detail and comparisons were made over a wide range of signal strength. It was found that the equal heterodyne gave a signal which was from four to ten times as loud as that given by the chopper, the greatest amplification being obtained on the weaker signal.

The four-fold amplification generally attributed to the heterodyne was fully realized, but the ten-fold amplification was rather unexpected but easily explained.

The second series of measurements involved the determination of the signal strength of the equal heterodyne, and that obtained when the locally generated radio frequency current is increased to its critical value, i.e., to the point of maximum response. This system has been termed by Armstrong, the optimum heterodyne. The results indicated that the magnification varies over a very wide range and depends on some inverse power of the signaling current. On the stronger signals the response for the best adjustment of local current was only about one and one-half times as great as that of the equal current; whereas, on the weaker signal the response was at least fifty-five times, and the general shape of the curve indicated that the increase would be greater for weak signals, perhaps several hundred fold.

The next series of measurements were made for the purpose of determining the relation between the maximum signal strength obtainable with a simple electron relay with the separate heterodyne, and the signal obtainable when the relay is supplied with a regenerative circuit and operated as self-heterodyne, i. e., the Armstrong circuit.

The results obtained were extremely irregular, due to the critical adjustment necessary for the self-heterodyne, but there was found to be an average amplification of about fifty times with respect to the signals produced by the external heterodyne. It was also brought out that the so-called "ultra audion," in spite of the claims of its patentee, is a distinctly regenerative circuit and gives an amplification about fifty times greater than the simple connection with the external heterodyne.

Summed up in its entirety, the total amplification obtained by the regenerative oscillating relay as compared to the signal obtained with the same relay in a simple circuit with a chopper, was found to be taking average values about *five times for the equal heterodyne,* a further magnification of at least *twenty times for the optimum heterodyne,* and finally, a *fifty-fold magnification by the operation of the regenerative circuit,* making a total of approximately *five thousand.*

In view of the two main theories concerning the operation of the heterodyne, namely, that the amplification to be obtained by this system is unlimited, the practical limit being determined by the disturbances produced in the receiving system by the local frequency and the current-carrying capacity of the detector, and the second theory, that of Liebowitz, which states that the maximum true amplification of the heterodyne is four, which is obtained when the local current is equal in amplitude to the signaling current, the author attempts to explain the true nature of the heterodyne phenomena. The latter theory (that of Liebowitz) says further that any increase in response beyond the factor of four obtained by an increase in local current is due to some improvement in the efficiency of the receiving apparatus. It is shown by Armstrong that the true key-note of this increase of amplification lies in what may be called "heterodyne characteristic," i. e., the relation between the telephone signal strength and the ratio of the local to the signaling current.

A number of experimental curves were taken and in all cases beyond the one to one point, an increase of the local to the signaling current produced a very rapid increase in the telephone signal strength which rose to a maximum value rather rapidly and fell off to zero. This critical point in the curve is explained, by Armstrong, to be due to the shape of the rectifying or valve characteristic of the electron relay which he discusses at some length. He remarks finally:

"The shape of the valve characteristic also explains the interesting fact discovered by Dr. Austin, that the plate current is proportional to the second power of the radio frequency current in the non-oscillating state but to the first power in the oscillating state. In the non-oscillating state, the rectification takes place on the lower part of the curve where the square law holds (with reference to zero current). In the oscillating state the operation takes place on an upper part of the curve which, for small changes of potential, is practically a straight line.

"It is evident from this that a regenerative receiver in the oscillating state delivers to the telephones an amount of energy which is proportional to the energy of the radio frequency current in the antenna. The relative amplitude of stray to signaling current in the telephones is therefore independent of the size of the antenna, and barring physiological effects and the possibility of overloading the tube, the readableness of signals should also be independent of antenna size. In ordinary practice this seems to be the case.

"In the non-oscillating state the first power proportionality between antenna and telephone energies is maintained only for strong signals. For weak signals or even moderately strong signals the telephone current will fall off very rapidly with a decrease in antenna energy with the result that the smaller the antenna the greater the ratio of the intensities of srays to signals in the telephones. Hence it follows that the larger the antenna the more readable the signals."

A LOW FREQUENCY RECTIFIER

GEORGE S. MEIKLE, of Schenectady, N. Y., has developed an apparatus for the rectification of low frequency currents. The device shown in Figure 2 is an extension of a former conception in which the inventor showed a filamentary cathode inserted in a vacuum valve with an anode, the device being used as a rectifier. Although the earlier construction was convenient and operative, it sometimes had a very short life, due to breaking of the filament caused by localized electrical erosion.

Mr. Meikle uses a rugged main cathode and a separate or auxiliary electrode which operate in conjunction to spring a starting arc which heats the cathode to incandescence preliminary to starting the main arc. This rectified current may be used for any desired purpose; for example, to charge a storage battery as shown at arc 2.

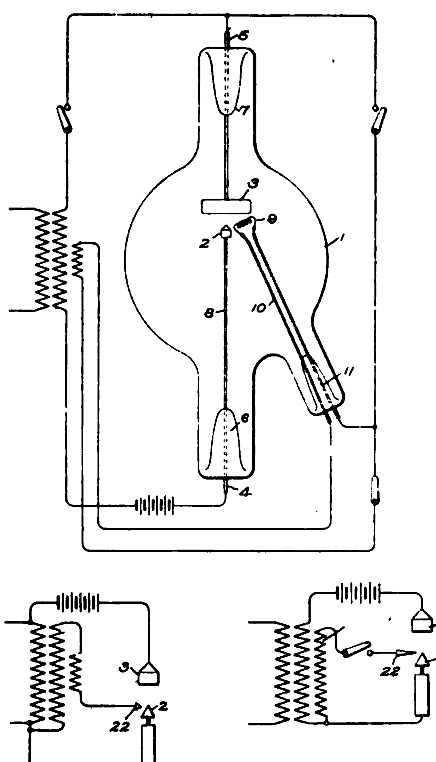


Figure 2

It is to be especially noted that the main electrode, 2, consists of a very rugged conductor so that a small amount of electrical erosion will not shorten the life of the device. The starting electrode or filament, 9, is only used for short periods and therefore is substantially unaffected by erosion.

There are several means by which the same current which is applied to the rectifier can be stepped down through a third winding and made to heat the filament for starting purposes. In one arrangement shown in the right hand lower drawing of Figure 2, a high potential discharge occurs from the pointed electrode, 22, to the electrode, 2, as the anode. This discharge heats the electrode, 2, to incandescence, whereupon the main arc starts between the electrode, 2, as cathode and the electrode, 3, as anode and a rectified current is therefore supplied.

In the Service

CAPTAIN EDWIN H. ARMSTRONG

Something About the Young Inventor of the Regenerative Circuit Who Has Received a Commission in the Signal Corps

EDWIN H. ARMSTRONG, who has won considerable recognition in wireless because of his invention of circuits in connection with receiving apparatus, has been appointed a captain in the United States Signal Corps. He also has the distinction of being the first recipient of the medal of honor of the Institute of Radio Engineers.

Captain Armstrong was born December 18, 1890. He was graduated from Columbia University in 1913 with the degree of E. E. and since then has been associated with Professor Michael I. Pupin in the work of the latter at Columbia laboratories.

The invention of Armstrong circuits in connection with wireless reception took place in 1912. This was during the period when he was active as an amateur and consequently experimenters have shown considerable interest in his progress in the wireless field. The medal which he received was awarded in acknowledgment of his invention. It was the outcome of the action of the Board of Direction of the Institute of Radio Engineers who decided to award annually a medal of honor to persons who had distinguished themselves by unusual achievements in radio telegraphy and telephony.

In his testimony before the Congressional hearing on the proposed bill to regulate wireless communication Professor Pupin referred to the invention of Captain Armstrong in these words:

"In 1910 Dr. Austin, director of the Wireless Research Bureau of the Army and Navy, published a paper in which he compared the efficiency of the various types of receivers. Among the receivers he examined was a new one, the so-called audion, the very audion receiver which is today used almost universally. Dr. Austin found that this audion was one and a half times as good as the best receiver they had prior to that time . . . . At that time a young inventor (Captain Armstrong) to whom I refer was a student in Columbia University, a sophomore . . . . In 1912 when this student graduated . . . . he had the invention, a very simple thing, consisting in taking that audion tube and by a simple transposition of the circuits making it five thousand times as sensitive as the one which Dr. Austin examined."

Captain Armstrong is a director of the Institute of Radio Engineers and President of the Radio Club of America.

Signal Officers' Training Course

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

SIXTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

THE war has brought about sweeping changes in the organization of the Signal Corps. In former days a field battalion comprised a radio company and a telegraph company, each of 3 officers and 75 men. The total strength of this branch of service in the United States Army was 46 officers and 1,212 men. This was in the days, but a short time since, when we conceived the regular army of the United States at a maximum strength of 100,000. Now that the figures of our fighting forces are mounting up into the millions, the Signal Corps shows corresponding increase. It is purposed to build up this technical corps to a strength of 150,000 men, or half again as large as the entire army, as we formerly conceived it.

With the enormous increase in personnel have come corresponding changes in organization. The field battalion now consists of three companies, as follows: A wire company, containing 1 captain, 2 first lieutenants, and 75 enlisted men; a radio company, containing 1 captain, 2 first lieutenants, and 75 enlisted men, and an outpost company containing 1 captain, 4 first lieutenants, and 75 enlisted men. The battalion is commanded by a major, with a first lieutenant as battalion adjutant and quartermaster, and an enlisted headquarters detachment of 13 men.

The specific duties of these units are covered in detail in the author's "Military Signal Corps Manual," in which volume not only the tactical use of companies is dealt with but instruction in technical employment given in detail. The following outline of the general use of battalion units and some details of the drill of the radio company are abstracted from this work.

OBJECT AND COMPOSITION OF FIELD SIGNAL TROOPS

Field Signal troops comprise those Signal Corps units permanently assigned to divisions, army corps, and armies for the purposes of establishing and maintaining tactical lines of information and for transmitting over these lines such information as is incident to operations in the field.

One field battalion is assigned to each division, one to each army corps, and such number as is necessary to each army.

Field signal troops assigned to army corps and armies are intended to furnish a reserve for the field battalions in advance, to supplement the work of the latter when necessary or desirable, and for use with separate brigades and expeditionary forces. In emergency, these troops may assist telegraph troops in establishing and maintaining the necessary strategical lines of information.

Field signal troops assigned to army corps and armies normally constitute a reserve and, except for the use of wagon radio sets for communicating with divisions, their active employment otherwise is to be regarded as exceptional.

FUNCTION OF THE WIRE COMPANY

The wire company is the field signal organization used by the commander of a division for establishing and maintaining those tactical lines of information which radiate from headquarters, and which serve, in general, to connect these headquarters with the major subordinate units. Normally the wire company is used to connect division headquarters with the headquarters of the various brigades within the division, with the divisional artillery, and, in some cases, with the divisional trains. Opportunity for its use in maintaining communications with the divisional cavalry will occur so rarely that its employment in this manner is prohibited except in emergency.

FUNCTION OF THE OUTPOST COMPANY

The general function of the outpost company is to extend the lines of information in the division forward of the brigade. Specifically, its normal function is to furnish telephone communication between the infantry brigade commander and his regimental commanders in combat. In addition, it may be called upon to supplement the work of other companies of the field battalion wherever the same may be necessary or desirable.

Conditions of employment will probably cause the frequent dispersion of the fractions of the company among the divisional units for long periods of time. For this reason the personnel should be inculcated with the highest possible degree of discipline and should have unquestioned ability to maintain itself in the field.

FUNCTION OF THE RADIO COMPANY

It will now be well to consider the operations of one unit in the field battalion from the viewpoint of its training under drill regulations to acquire field efficiency. As with the training of technical combatant troops, the subject is a broad one and comprises instruction from the time when the recruit learns his duties as an individual soldier, through his instruction in technical features of the apparatus he is required to handle, and his finished instruction in drill regulations as a mounted soldier. Some of these subjects have been covered in outline in previous articles; in considering the radio company, therefore, we will confine the instruction in this article to a few details of drill regulations which will throw some light on the handling of the unit in training for field service abroad.

Employment

The radio company is used by the commander of a division for maintaining communication with adjacent columns with the divisional cavalry, and in other instances when distance, the character of the service, and the nature of the terrain prevent the laying of wire lines. The radio company usually serves to connect division headquarters with the divisional trains and, pending the construction of semi-permanent lines, with the radio station at army corps headquarters in the

rear. These radio facilities may also be used to intercept messages sent by the enemy or to interfere with the operation of his radio stations.

Organization

The radio company is organized into the necessary headquarters and company staff, two platoons of two pack radio sections each, and one wagon radio section.

For drill the company is formed, as above, the wagon radio section forming a provisional platoon on the left of the company. In the field or on the march the company instrument wagon forms a fourth platoon under command of the supply sergeant.

The organization, in detail, is as follows:

1 captain.
2 first lieutenants.
1 master signal electrician.
1 first sergeant (sergeant, first class).
1 supply sergeant (sergeant).
1 stable sergeant (sergeant).
1 mess sergeant (sergeant).
1 horseshoer.
1 clerk (corporal).
1 farrier (corporal).
1 saddler (corporal).
1 mechanic (corporal).
2 cooks.
1 driver (private, first class).
2 buglers (private, first class, one acting as guidon).
4 radio sections, pack.
1 radio section, wheel.

DUTIES OF INDIVIDUALS

The captain commands the company and is responsible for its training and efficiency.

The lieutenants command platoons, and will be assigned to such other duties as the captain may deem necessary.

The master signal electrician is responsible to the captain for the condition of the technical equipment of the company. To this end he will make frequent and regular inspections of same and, when parts of the technical equipment are found or reported unserviceable, will make or supervise the necessary repairs. Under the direction of the captain, he will order such precautionary and corrective measures as he may deem advisable concerning the care and repair of technical equipment. Master signal electricians also act as substitute chiefs of platoons.

The first sergeant is the assistant of the captain, and is responsible to him for the general order, police and discipline of the company. In action he remains with the captain and under his immediate orders.

The supply sergeant is responsible to the captain for the care and preservation of the material not issued to the sections.

The stable sergeant is responsible to the captain for the general care of the public animals assigned to the company, the good order and police of the stables and picket lines, and the conduct of the stable personnel, when on duty.

The mess sergeant is responsible to the captain for the efficient and economical handling of the ration, for the conduct of the kitchen personnel when on duty and for the cleanliness of the company kitchen and surroundings.

The mechanics, under the orders of the supply sergeant, are responsible for the repair of the material pertaining to the company.

Chiefs of sections command the sections and will be held responsible to the captain for the condition of their equipment and the training and efficiency of their sections. They will make, or cause to be made, such minor adjustments or repairs to technical equipment as can be effected by the personnel of the section, promptly reporting more serious deficiencies to the master signal electrician.

The drivers are directly responsible to their chiefs of sections for their animals, harness and equipment. They will report at once to their chief of section any injury to animals and material.

The operators are responsible for the serviceable condition of their instruments and will report at once to their chiefs of sections any need of repairs.

Messengers are responsible for the delivery of all messages, no matter what the conditions.

THE PACK RADIO SECTION

Composition

The pack radio section is normally composed of 10 mounted men and 3 pack mules, designated the "generator" mule, the "chest" mule, and the "kit" mule. If a fourth pack mule be present with the section it will be designated the "supply" mule.

The organization, in detail, is as follows:

1 section chief (sergeant, first class).
2 operators (1 sergeant, 1 corporal).
1 messenger (private, first class).
4 antenna and counterpoise men (1 corporal, 3 privates, first class).
2 horseholders (1 private, first class, 1 private).
Total, 10.

Formation

The section is formed in column of twos. Each mule is led by one of the men and, with its driver, forms a two.

Posts and Duties of Individuals

The chief of section is on the left of the leading two except that when the section is acting alone he may go where his services are most needed.

The other men are numbered from 1 to 9, Nos. 1 and 2, the operators, form the leading two, No. 1, the sergeant operator on the right. These are followed by Nos. 3 and 4, horseholders, and No. 5, the messenger, leading, respectively, the kit, generator, and chest mules. Mule drivers march on the left of their led mules. The mules are followed by Nos. 6, 7, 8, and 9, antenna and counterpoise men, in column of twos with Nos. 6 and 8 on the right. It is the duty of No. 6 to observe the packs and keep up any lagging mules. The antenna squad corporal is No. 9. If a supply mule be present it is led by No. 6, and the duty of observing packs and keeping up lagging mules devolves upon No. 8.

The pack radio section in the field, showing method of transporting equipment by mule pack

The U. S. Army pack radio station open and working, an illustration of the completed erection of field equipment in accordance with drill regulations

It is the duty of all men so far as they may be able in addition to leading their own mules, to urge forward the mule immediately in front.

TO OPEN STATION

Being in normal formation: 1. **Open station,** 2, **DISMOUNT.**

At the command *Open Station,* Nos. 3 and 4 stand fast; No. 1 executes individual right about, chief of section and No. 2 left about; No. 6, moving along right flank of column, comes in alongside No. 1; No. 8 comes in alongside No. 6; No. 7, moving along left flank of column, comes in alongside the chief of section; No. 9 comes in alongside No. 7; No. 5 leads his mule left front into line on No. 4. At the command *Dismount,* all pass reins over horses' heads and dismount. Chief of section, Nos. 1, 2, 6, 7, 8, and 9 turn their horses over to No. 3, and proceed to unpack the generator and chest mules. Nos. 4 and 5, holding their mules in place, move their horses out of the way. No. 1 working on right side and No. 2 on left side, with No. 8 assisting, unpack generator mule. No. 6 working on right side and No. 7 on left side, No. 9 assisting, unpack chest mule. The equipment will be placed on ground 1 yard in rear of mules, iron ferrules of mast pointing to rear. Nos. 4 and 5, after seeing that all loose straps and cinchas are crossed over mules, lead off their horses and mules and turn them over to No. 3. As soon as the mules are unpacked Nos. 6 and 7 open antenna bag and distribute antenna reels, the chief of section places top insulator into top joints of mast, and distributes pins to Nos. 1, 2, 6, and 7, who secure antenna, snap their antenna into insulator, and reel out their antenna wires. No. 1 goes to right and No. 2 to left of horses, their antenna wires forming an angle of 90 degrees, No. 6 opposite No. 2 and No. 7 opposite No. 1, and then face mast and watch the chief of section for signals. The chief of section and No. 4 then raise the mast hand over hand; No. 5, assisted later by No. 4, connects up chest and generator, antenna, and counterpoise leads. As soon as bottom joint is in place and mast vertical, chief commands **tie in,** when the antenna men secure their antenna cords to pins and return to mast; Nos. 8 and 9 reel out the counterpoise directly under the antenna wires. In their absence this will be done

by Nos. 6 and 7. The chief of section details the necessary operators, messengers, men to turn generator, guards to protect antenna and over animals.

Each man, having a permanent assignment of duty, soon learns to do his part quickly, and after the men have become proficient in handling the equipment the entire operation of unpacking and opening station may be effected by the command *open station.*

TO CLOSE STATION

At the command *Close Station,* the chief of section and No. 4 immediately start lowering the mast; Nos. 1, 2, 6, and 7 move rapidly to their respective antenna cords, face the mast, and watch for signals. They place their antenna pins in leggings and, when the mast is down, reel up without waiting for command. The chief of section unsnaps all antenna wires from top insulator, throws them clear, and then reels up antenna from top insulator, throws them clear, and then reels up antenna lead. No. 5 closes and secures chest for packing, while No. 4 attends to generator, after which they secure their respective horses and mules and spot the latter for packing. Nos. 8 and 9 reel up the counterpoise and place it in bottom of bag. In their absence this will be done by Nos. 6 and 7. The chief of section packs away antenna reels and secures pins. Nos. 1 and 2, No. 8 assisting, pack generator mule. Nos. 6 and 7, No. 9 assisting, pack chest mule. Men, when they find themselves no longer of assistance in packing mules, will promptly secure their horses, mount up, and form column, No. 2 being the base. The section forms in column, facing in the same direction as when open station was given.

THE WAGON RADIO SECTION

Composition

The wagon radio section is normally composed of 20 men, and one wagon radio set drawn by four horses. All men are individually mounted except the driver and the engineer, who ride on the wagon.

The organization in detail is as follows:

1 section chief (sergeant, first class).
3 operators (1 sergeant, 2 corporals).
3 mast men (1 sergeant, 2 privates, first class).
1 engineer (corporal).
8 antenna, counterpoise and guy men (1 corporal, 7 privates, first class).
1 messenger (private, first class).
1 driver (private, first class).
2 horseholders (privates).
Total, 20.

Formation

The mounted men of the section, less the chief of section and one horseholder, are formed in column of fours. The wagon is posted so that the lead horses are two yards in rear of the column of fours and in such a position that the pole of the wagon is in prolongation of the interval between the numbers 2 and 3 in the mounted ranks.

Posts and Duties of Individuals

The chief of section is on the left of the leading four, two, or file, except that when the section is acting alone he may go where his services are most needed. Beginning with No. 1 on the right of the leading four and going to the left of each succeeding four, the remaining mounted men of the section are numbered consecutively from 1 to 17 for the purpose of describing their duties. Nos. 1, 2, and 3 are operators; No. 1 being the senior operator; No. 4 is the messenger; Nos. 5, 6 and 7 are the mast men; No. 5 being the senior and in charge of the mast detail; No. 8 is a horseholder; Nos. 9, 10, 11, and 12 are the antenna men; No. 9 being the senior and in charge of the antenna and counterpoise detail; Nos.

13, 14, 15, and 16 are the counterpoise and guy men; No. 17 is the remaining horseholder and marches on the left of the leaders except that on the march he may ride in rear of the wagon.

The Wagon Radio Set

The wagon radio set is carried on a pintle-type wagon. It consists of the necessary technical radio apparatus, an engine, a dynamo, a jointed mast, antenna any guy ropes, and the counterpoise. The technical radio apparatus is attached to the front, and the engine and dynamo to the rear element, and electrically connected with the instruments by cable. On the rear vehicle are also carried the mast, consisting of 10 sections 8 feet in length; the antenna, which has nine cords, one of which is the connecting cord; two sets of guy ropes, four in each set; and the rubber insulated wire counterpoise, consisting of eight branches.

Drill of the Section
Maneuver

The section is maneuvered by the methods and means prescribed for the wire section, where applicable.

TO OPEN STATION

The chief of section indicates the location of the station and commands: 1. **OPEN STATION.**

At this command the driver halts and unhitches his team. The chief of section moves the mounted men a sufficient distance to be out of the way of the antenna and guy ropes when the mast is raised and dismounts them. The horses are turned over to the horseholders (Nos. 8 and 17) and the remaining men proceed to unpack the wagon, each man assisting in unpacking and making ready that part of the equipment which it is his duty to handle in establishing the station.

Nos. 1 and 2 place the counterpoise in position; Nos. 3 and 4 take position on top of the front element of the wagon prepared to raise the mast; Nos. 5, 6, and 7 unpack the sections of the mast and place them on the ground convenient to the point at which the mast is to be raised; Nos. 9, 10, 11, and 12 unpack the antenna and pins or stakes and pay out the antenna under direction of the chief of section; Nos. 13, 14, 15, and 16 unpack and pay out the two sets of guy ropes under direction of the chief of section.

As soon as the top joint of the mast is unloaded, No. 7 places the top insulator, with antenna attached, in top of the joint and raises it vertically to Nos. 3 and 4. He then places the remaining joints successively in place and assists Nos. 3 and 4, who raise the mast vertically. The five smaller joints form the upper part of the mast. No. 7 also places the guy rings in place at the top of the fourth and seventh section.

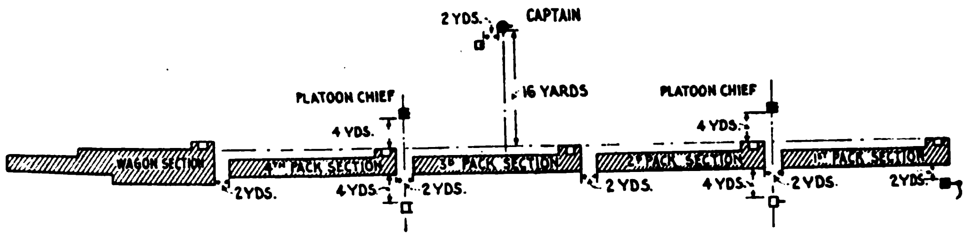
No. 9 should be in front of the wagon, with Nos. 10, 11, and 12 in sequence to his left, in a circle around the mast. This will bring No. 11 opposite No. 9, and No. 12 opposite No. 10. Each man holds two adjacent antenna cords, carries necessary pins in his leggings and a hammer in his belt. Nos. 13, 14, 15, and 16, the guy men, each with an upper and lower guy rope, a hammer, and necessary pins take position, in a corresponding manner, in a smaller circle around the mast, No. 13 being between No. 9 and the mast. This will bring No. 15 opposite No. 13, and No. 16 opposite No. 14. As the mast is being raised the antenna and guy men, standing facing it, will keep it vertical by proper handling of the antenna and guys, under direction of Nos. 5 and 6. No. 5 will direct 9, 11, 13, and 15, and No. 6 will direct 10, 12, 14, and 16. When it is desired that an antenna or guy be pulled out, the command *out* will be used, as No.—*Out*. When it should be slacked off, the command *in* will be used. The guy ropes which each guy man holds are referred to, respectively, as *upper* and *lower*.

When the mast is up to the required height the chief of section commands **TIE IN.** At this command the guy men, with the assistance of Nos. 6 and 7, if

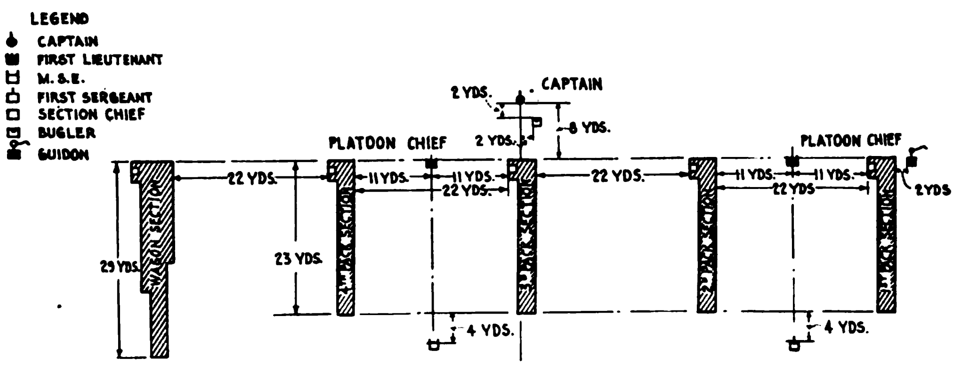
necessary, drive pins in the ground and secure their guys. Antenna men, with the assistance of Nos. 6 and 7 or guymen, if necessary drive a pin in the ground and secure the proper antenna cord. They then secure the remaining cord in a similar manner midway between those first placed. In doing this all move to the right from the antenna cord first secured.

As soon as the command *tie in* is given, No. 5 makes the proper connection for the antenna and counterpoise, while No. 6 supervises the tying in and sees that cords and ropes are kept taut.

As soon as the driver unhitches his team, the engineer will see that there is sufficient gasoline in the tank, oil in the cups, water in the proper receptacles (if the engine is water cooled), and connect the dynamo to the instrument by means of the cable and generally make ready to start the engine and dynamo.



Formation of the radio company in column



Formation of the radio company in line

When the mast is up the chief of section details the operators, messengers, and guards for the antenna and guys, and makes such disposition of the remaining men as the situation demands. If the station is to be maintained open any length of time, he also directs that the picket line be established or the horses otherwise disposed of.

The driver takes care of his team.

TO CLOSE STATION

At the command *close station,* the operator removes the antenna and counterpoise connections, the guy men take up the pins and hold the guys, each antenna man first takes up the pin and frees the end of the antenna cord which he last secured and turns it loose, then proceeds to his other antenna cord, pulls up the pin, and holds the cord while the mast is being lowered. The mast is lowered by the same men in the same positions as when being raised. Nos. 5 and 6 direct the antenna and guy men. The counterpoise men recover the counterpoise; the

engineer shuts off all valves, the driver brings his team close to wagon, and when the mast is down hitches it to the wagon. All men assist in packing the equipment which they unpacked. When all the apparatus has been securely packed the chief of section commands **stand to horse,** when all men proceed to their horses and obey this command. The men are then mounted and the section formed by the appropriate commands.

In opening and closing station, all men who have finished the duty herein assigned to them may be directed by the chief of section to perform such other duties as may be necessary.

THE RADIO PLATOON

The radio platoon is composed of two radio pack sections commanded by a lieutenant.

The interval between sections in the order in line is approximately 22 yards.

EMPLOYMENT IN THE FIELD

General

The main equipment of each pack radio section is one pack radio set actuated by a hand generator, and that of the wagon radio section is one wagon radio set actuated by an engine-driven dynamo. Component parts of these sets are as indicated from time to time in War Department orders. The company instrument wagon carries a spare pack radio set. The pack radio set has a range of 20 to 30 miles, depending on conditions. The set can be unpacked, the mast erected, station opened, and messages started in 2½ minutes. The wagon radio set has a range of 150 to 250 miles, depending on conditions. The set can be unpacked, the mast erected, station opened, and messages started in 10 minutes.

Assignment of Sections to Duty

In general, the wagon set remains with headquarters. The pack sets can be so disposed that the division commander can send to and receive messages from the divisional cavalry and other important units with which radio communication is desired.

The field battalion at army corps headquarters can, if desired, make use of the large and more powerful motor truck radio sets available there for keeping in touch with the advancing organizations.

Selection of Station Sites

The selection of station sites involves on the part of those charged with that duty a suitable reconnaissance of the terrain, knowledge of the possibilities and limitations of the station to be erected and a consideration of the tactical needs and probable developments. The locality for the station will be selected with as much care as the time available and conditions will permit.

High open ground as far from near-by hills as practicable is to be preferred, due regard being had for cover and security of the station. The nearer the station is placed to the commanding officer or to the headquarters of the command with which the section is serving, the better.

If not impracticable the site selected should permit the full spread of antenna and guy ropes. The greater the spread of the antenna wires, the farther they are from the ground and the greater the capacity.

Instructions for Those in Charge of Field Radio Stations

Be sure you know the organization which you are serving and the commander to whom you report and are responsible.

Familiarize yourself promptly with the call letters and locations of all stations with which you are in communication; likewise, with the location of your own troops and the names of commanders.

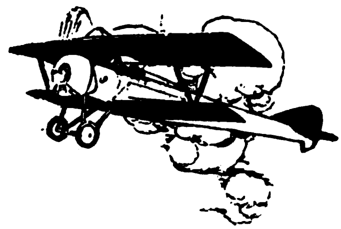
Arrange for the subsistence of the men and the foraging of the animals.

Constant attention to instruments and minor repairs made immediately will avoid serious breakdowns.

In receiving, attention to the insulation of the set and the mast from the ground is very important.

How to Become an Aviator

The Fourth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE

Author of "Text Book of Naval Aeronautics"

THE military aviator, to whom these articles are dedicated, can insure proficiency only through acquisition of a sound knowledge of the characteristics of design which govern the construction of an aeroplane.

No greater mistake can be made by a prospective military pilot than skimping the study of fundamentals. Air tactics in warfare, while a subject for military experts, are insoluably a part of the mechanics of aeronautics. While the manner of conducting air battles is subject to daily changes, it must be remembered that the effective observer or air fighter who creates new evolutions is logically one whose knowledge of engineering features of design is sound. Skill in manipulation of controls is essential of course, but it can readily be recognized that attempted creation of new tactics might well be fatal unless an aviator has an intelligent understanding of the limitations of his machine and what it can accomplish within the safety factor.

In this article some consideration will be given to the factors upon which a military aeroplane must base its superiority.

In the preceding installment fundamental principles of flight have been given; it now devolves upon the student to recognize that in military use of flying machines two important features are encountered:

(a) Superiority in climbing rate.

(b) Greatest speed.

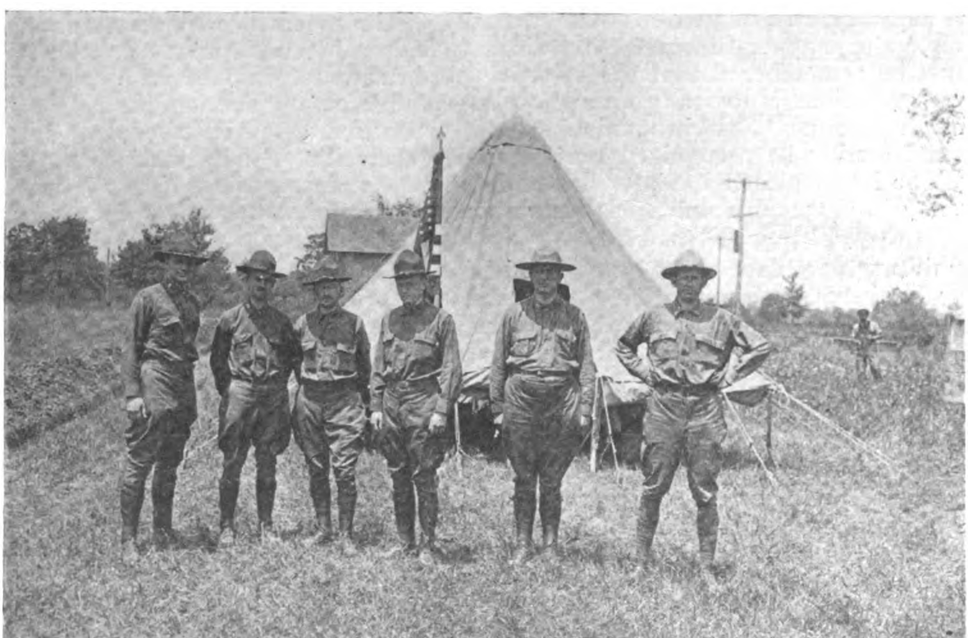
It is obvious that the machine which excels in speed and ability for fast climb will be most effective against the enemy. An aeroplane which attains speed at the sacrifice of climbing ability can be out-maneuvered by fast-climbing enemy aircraft in air battles, and the same is true of reverse qualities of climb versus speed. The combination of great speed with maximum climb is the ideal striven for in military aeroplane design.

As in all mechanical devices, however, the ideal must be subjected to compromise, and it is now purposed to apply the knowledge of fundamentals previously gained to consideration of the engineering factors which govern the design of machines for maximum climb and greatest velocity.

America's new material for the air fighting forces is well represented in this group of army flyers

Thus far in this series the reader should bear in mind that the aeroplane is being studied in two distinct divisions; viz., the **lifting surfaces** and the **propelling mechanism,** or (a) the aeroplane structure, (b) engine and propeller.

In the October issue the factors of lift-drift ratio were outlined and commented upon. As a thorough knowledge of the proportion of lift to drift is essential to an aviator, further considerations of design will be mentioned.



Officers of the Signal Corps, U. S. A., the greatly enlarged branch of service in which the aviation section is included

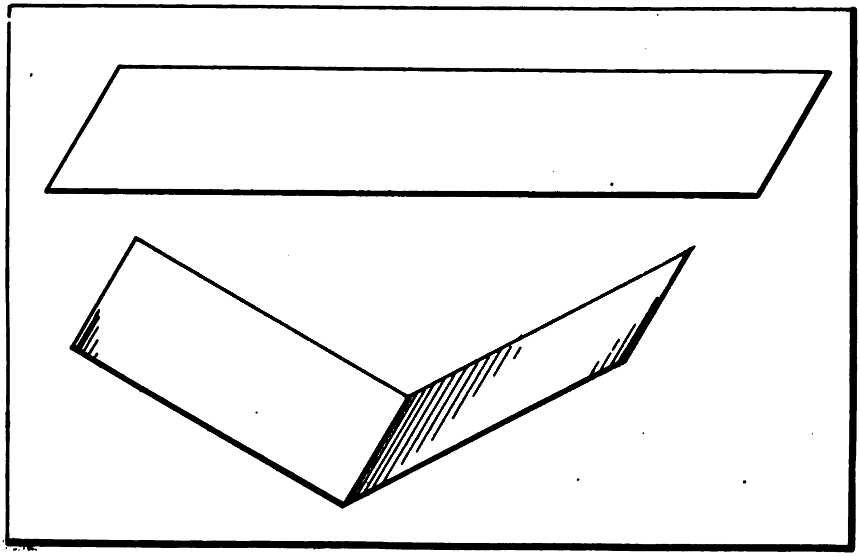


Figure 10.—Lifting surfaces of same area but different horizontal equivalent

The efficiency of the aeroplane structure is determined by the lift-drift ratio, and an item in relation to lifting surfaces which must be considered in addition to those covered in the October issue, is:

HORIZONTAL EQUIVALENT

This is determined by the arrangement of lifting surfaces and is important because lift (vertical component of the reaction) varies as the horizontal equivalent of the surface, but drift remains the same. That is, with reduction in horizontal equivalent (H. E.) of aerofoil the ratio of lift to drift is lessened.

Figure 10 gives front views of two lifting surfaces.

Both have the same surface area, but the upper, having its full horizontal equivalent, has the best lift-drift ratio.

The lower surface, being inclined from its center, has lessened H. E. and in consequence less lift.

Therefore, as the lower surface containing the same area as the upper surface, produces the same amount of drift, but less vertical lift, its lift-drift ratio is less than the upper's.

Sacrifice of efficiency in lift-drift ratio is often made to gain lateral stability; such employment of surfaces tilted from the center will be considered later.

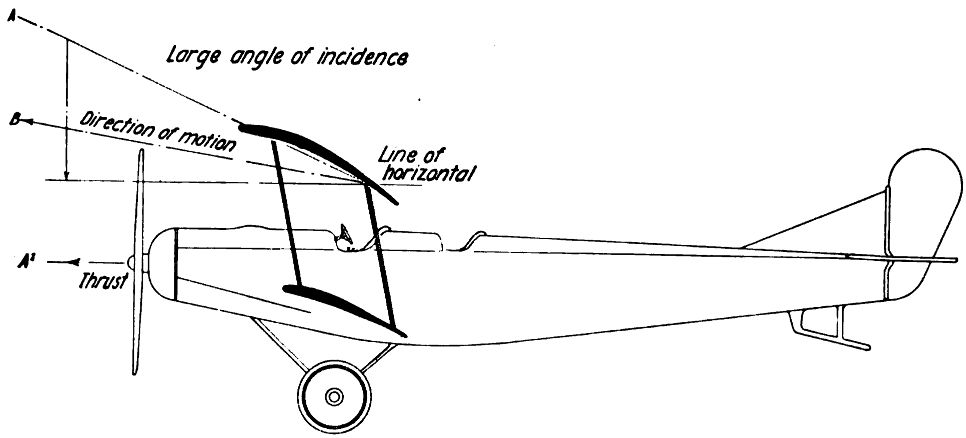


Figure 11.—Aeroplane designed for maximum climb

Aeroplane design is restricted by opposing essentials which require the aerofoil (lifting surface) characteristics and velocity to produce either Maximum Climb or Maximum Velocity. A compromise between the two is represented in all aeroplanes.

DESIGN FOR MAXIMUM CLIMB

The factors in an aeroplane designed for maximum climb are:

(a) Large aerofoil.
(b) Low velocity.
(c) Large angle of incidence to propeller thrust.
(d) Large angle relative to direction of motion.
(e) Large camber.

(a) *LARGE AEROFOIL—A Large area of lifting surface is required to engage the mass of air necessary for flight with a low velocity.*

(b) *LOW VELOCITY—Speed must be sacrificed to secure the best lift-drift ratio.*

(c) *LARGE ANGLE OF INCIDENCE TO PROPELLER THRUST—The most efficient aeroplane is one with inclined lifting surfaces propelled by horizontal thrust, therefore a flying machine for maximum climb to be driven along an upward sloping path with propeller thrust horizontal has its aerofoil at a large angle to the direction of the thrust.*

See A—A¹ figure 11.

In the preceding article it was shown that the lift drift ratio falls with increased velocity where the angle of incidence is great, because with a large angled aerofoil increased speed creates more eddies in the air reaction. These air reactions require power to produce them, yet they have no lift value; they therefore represent drift and lower the lift-drift ratio.

(d) *LARGE ANGLE OF INCIDENCE TO DIRECTION OF MOTION—With low velocity the angle's relation to the direction of motion should be large.*

See A—B, figure 11.

(e) *LARGE CAMBER—With low velocity and large angle of incidence the camber of the aerofoil should be large.*

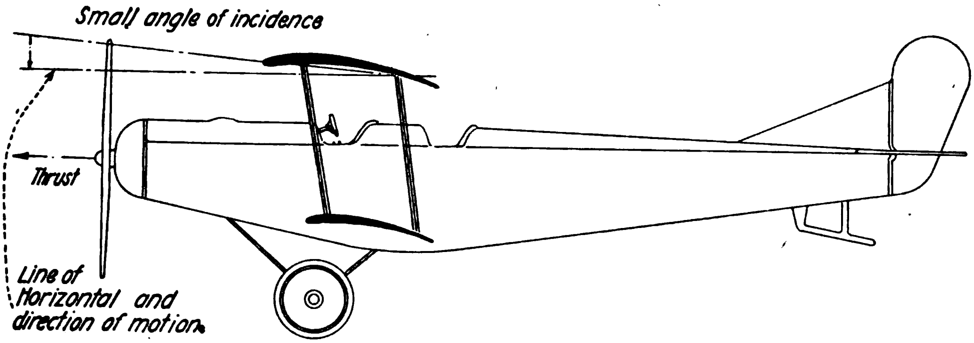


Figure 12.—Aeroplane designed for maximum velocity

The aeroplane designed mainly for speed has a small margin of lift at low altitudes when its propeller thrust is horizontal. In the rarefied atmosphere of higher altitudes engine efficiency is lowered and the margin of lift disappears. Then only horizontal flight is possible. Flying thus with its thrust horizontal it is at maximum efficiency, if loss of engine and propeller efficiency is not considered.

DESIGN FOR MAXIMUM VELOCITY

The factors in an aeroplane designed for maximum speed with given surface and power are exactly opposite the requirements for maximum climb. Thus:

(a) Small aerofoil.
(b) High velocity.
(c) Small angle of incidence to propeller thrust.
(d) Small angle relative to direction of motion.
(e) Small camber.

(a) *SMALL AEROFOIL—By its increased velocity the speedier propelled surface engages a greater mass of air in a given time and the required lift is secured with smaller surface.*

(b) *HIGH VELOCITY—Lessened aerofoil angle produces less drift, and velocity may be increased without loss in lift-drift ratio.*

(c) *SMALL ANGLE OF INCIDENCE TO PROPELLER THRUST—As both propeller thrust and direction of motion are horizontal, a small angle of incidence is most efficient for speed.*

(d) *SMALL ANGLE OF INCIDENCE TO DIRECTION OF MOTION—Where velocity is a consideration paramount to lift, a small angle of incidence is most efficient.*

(e) *SMALL CAMBER—Lessened camber at high velocity produces the best lift-drift ratio.*

The aeroplane built in accordance with the above is intended to possess only sufficient lift to get off the ground. The types illustrated on this and the preceding page are extremes, but the compromise of an aeroplane with climb and velocity equal considerations, i.e., a practical all around type, is designed by consideration of the factors disclosed in these examples.

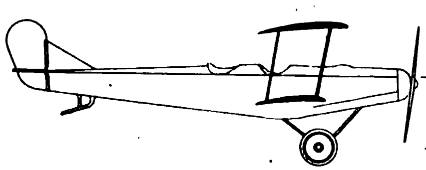
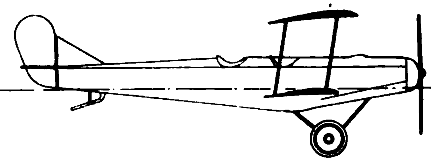


Figure 13a.—Minimum angle

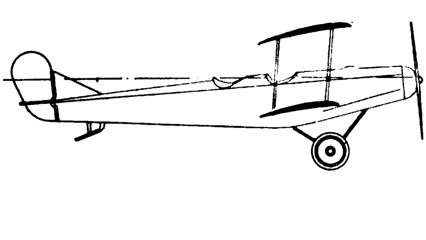


13b.—Optimum angle

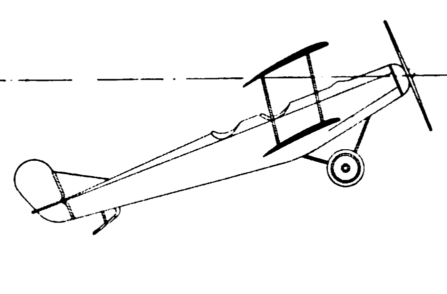
In the illustrations on this page an aeroplane of practical utility is shown at varying angles of incidence while in flight.

At low altitudes the aircraft shown has slight margin of lift when the thrust is horizontal.

The fighting machine usually flies at an altitude where maximum velocity is gained at sacrifice of maximum lift. It is obvious that with slight margin of lift at low altitudes, the margin of lift disappears with the rise of the aeroplane, because of loss of engine power in the rarefied air. But when the machine arrives at the altitude where horizontal flight is just possible, it is given its maximum velocity because, even though engine and propeller efficiency is lowered, the margin of lift has disappeared and the surfaces are at their best flying efficiency for horizontal flight.



Figures 13c.—Angle of best climb



13d.—Maximum angle

ANGLES OF INCIDENCE IN FLIGHT

Minimum—(See figure 13a). The angle of the aerofoil is the smallest at which, with amount of power and area of surface fixed, the machine can maintain greatest velocity in horizontal flight at low altitudes.

An aeroplane having less camber and smaller angle of incidence, i.e., so designed that the margin of lift is negligible, or just sufficient to maintain horizontal flight, would attain greater velocity with the same surface area and power.

Optimum—(See figure 13b). Here the axis of the propeller is horizontal and the angle of incidence that which is required for best lift-drift ratio. Velocity is lessened at this angle, at which slight climb is developed at low altitudes.

Best Climb—(See figure 13c). This angle is about midway between maximum and optimum angles of incidence. Here the increased angle has added to the drift and thereby decreased the velocity.

With the angle fixed, a decrease in velocity lessens the drift, but where the angle has been increased the lift thereby gained in a measure offsets the loss in lift through lessened velocity.

Beginners should never exceed the angle of best climb.

Maximum—(See figure 13d). Horizontal flight is just possible at this angle, because drift has been greatly increased and velocity materially lessened in consequence.

If the angle were further increased the lift-drift ratio would be so lowered that the lift would be less than the weight and the aeroplane would fall. This fall is known as the "pancake."

In the December issue the problems of stability in flight will be considered and explanations given of the arrangement of devices to insure correction of disturbances caused by the treachery of the atmosphere, the flight medium.

MILITARY AIRMEN

BRIGADIER GENERAL BENJAMIN D. FOULOIS

He says:

"Wireless men are indispensable in connection with aeronautics, particularly in aero reconnaissance."

"WIRELESS men are indispensable in connection with aeronautics, particularly in aero reconnaissance," is the important message to readers of THE WIRELESS AGE sent by General Foulois, 36-year-old commander of the army's aviation section.

An excellent type of the American airman, young but widely experienced and wholly fearless, is the army's air chief. Few officers have risen so rapidly. A native of Connecticut, Foulois early in his career was sent to the Philippines where he served five years, taking part in upwards of fifty skirmishes.

In view of the fact that the United States was the first country to use aircraft in its army, the early official flights made by Foulois are doubly historic. He was selected by the Wright Brothers to be the passenger in the first army test flight in history in any country. This flight was between Fort Myer and Alexandria, Va., a distance of seven miles. In 1911, when Robert J. Collier lent his Wright biplane of the old type to the Government for official tests, flights were made by Foulois, assisted by Phil Parmalee, in the vicinity of Eagle Pass, in Mexico, which attracted wide attention. In the same year Foulois was placed in charge of all aviators connected with the National Guard.

It is not generally appreciated that the first flying in active war service was done by an American airman in the Mexican campaign. When Villa made his famous raid, sacking Chihuahua City, Foulois chanced to be at San Diego. He was detailed with six machines and a squad of picked flyers to enter Mexico. The dangers and difficulties faced by these pioneer army airmen were unprecedented. The dry heat caused the propellers to fly apart, the water boiled in the radiators, while unexpected air currents rendered air navigation extremely perilous. Despite these handicaps excellent work was accomplished.

One of the most daring flights was made by Foulois himself while carrying General Pershing's dispatches from San Antonio, Texas, to the American consul at Chihuahua City, Mexico. The reception of the American airmen was very uncertain, for feeling ran high. Foulois dropped down unexpectedly and quite defenseless in the Mexican stronghold. On landing he hurried under armed guard to the Consulate, and hurrying back sprang into his machine and flew away so quickly that the populace had not had time to act. During another air trip he camped for two nights in a country infested with bandits.

General Foulois, although a veteran airman of such varied experience, is today but thirty-six years of age. It is to such men as he that the country looks with confidence to establish American supremacy in the air in the great world war.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE VII

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

Editor's Note.—This is the seventh installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of The Wireless Age. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively. In the next issue the phenomena of electrostatic capacity will be considered, together with its relation to the production of high frequency alternating currents.

THE ELECTRIC MOTOR

FUNDAMENTAL FACTS CONCERNING THE MOTOR

(1) We have already mentioned that, essentially, there is no difference in the construction of a direct current dynamo and a direct current motor.

(2) If a direct current dynamo be connected to **an external source of direct current,** its armature will be set into rotation, converting the **electrical power supplied to it into mechanical power,** i.e., it will become **a motor.**

(3) We have shown a dynamo armature when set into rotation induces an electromotive force in each wire and it makes no difference whether the armature be driven by an external source of mechanical power (such as a steam engine) or whether it be set into rotation by an external source of electric current. In either case an E.M.F. will be generated, but in the case of an electric motor this E.M.F. will be **counter to** or act against the driving E.M.F. This back E.M.F. is termed, **counter electromotive force** (abbreviated C.E.M.F.). The generation of this counter E.M.F. of course follows the same law as the dynamo, namely, the greater the speed, or the stronger the field flux with a given speed, the greater will be the C.E.M.F.

(4) Since the counter E. M. F. acts against the driving E. M. F. it is readily seen that **the greater the C.E.M.F. the less will be the current flowing through the armature.**

(5) Because the counter E.M.F. thus governs the amount of current admitted to the armature, we see that it is an important factor in motor design and operation.

(6) It is now evident that the **effective resistance** of a motor armature when in rotation, is quite different than its D.C. resistance when it is standing still.

(7) For instance, the steady resistance of a motor armature when stationary may be .05 ohm, but its effective resistance when rotating at normal speed may be 5 ohms.

(8) Suppose, then, we connected this stationary armature directly to a source of 110 volts D.C. According to Ohm's law a current of $\frac{110}{.05}=2200$ amperes will flow. A current of this amount obviously would immediately destroy the armature, melting both the brushes and mains leading thereto (provided the circuit was not protected by a fuse).

(9) We also see that when in full rotation, the current would equal $\frac{110}{5}$ or 22 amperes. It should now become apparent that some safety measure must be taken to protect the armature of the motor during the starting period. In fact, it is necessary to insert an external variable resistance coil in the circuit to reduce the strength of the starting current. This device is known as a **motor starter.**

(10) A **motor starter** consists of a number of **resistance coils** connected to the contact points of a multipoint switch. At the start of the motor all the resistance coils are connected in series with the circuit, but as the armature increases its speed these coils are progressively cut out of the circuit by the operator, until finally the full voltage of the external source of current is applied to the armature terminals.

(11) Motor starters may be **hand-operated** or **automatically operated.** If, for instance, it is not convenient to place the motor starter near to the operator, an automatic starter is employed which is placed near to the motor and a small control circuit leads therefrom to the controlling point.

(12) The running speed of any direct current motor can be regulated within reasonable limits by means of a variable resistance coil known as a **field rheostat** or **field regulator.** This is connected in series with the shunt winding and an increase of its resistance i.e., a reduction of the field current will cause the motor to increase its speed. This is accounted for by the fact that the motor armature generates less counter E.M.F. when the field current is reduced.

(13) It is desirable, under fluctuating loads, that a motor maintain a **constant speed.** If the load does not vary too rapidly an ordinary shunt wound motor will afford the necessary speed regulation, but if a severely fluctuating load is applied, a special winding must be provided to maintain the necessary speed regulation. A motor wound for such regulation is said to have a **differential field winding,** that is, its field circuits consist of a series and a shunting winding through which the current circulates so that their magnetic fields will oppose.

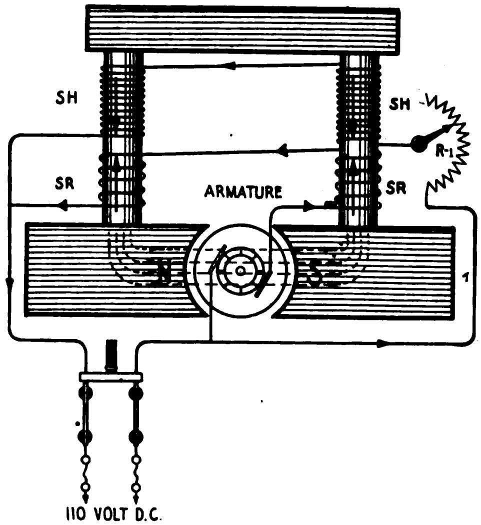


Figure 45

OBJECT OF THE DIAGRAM

To show the fundamental circuits of a differentially wound motor.

PRINCIPLE

By magnetically opposing the shunt and series field windings of a motor, proper design enables the flux of the series winding to act against the flux generated by the shunt winding according to the load to which the motor is subjected. A practically constant speed is thus maintained.

DESCRIPTION OF THE APPARATUS

The cores of the field poles N, S, have a series winding, S R, connected in series with the motor armature to the line and a shunt winding, S H, connected in shunt to the power mains. The current circulates through these windings in opposite directions.

A field rheostat, R-1, is connected in series with the shunt field coils.

OPERATION

An increase of the load applied to the armature will cause a slight reduction in speed, and owing to the reduced counter E.M.F. in this circumstance, increased current flows through the armature coils and series winding. This action weakens the flux generated by the shunt winding, causing a still greater reduction of the counter E.M.F. which permits increased current to flow through the armature. This regulation takes place according to the load imposed. A practically constant speed may thus be maintained.

QUES.—How may initial adjustments of speed be made with this motor?

Ans.—By means of the field rheostat, R-1. An increase of resistance at R-1 will increase the motor speed, whereas a decrease of resistance will reduce the motor speed.

QUES.—In what connection with wireless telegraph apparatus does a motor of this type have particular application?

Ans.—The motor employed to drive the generator in a motor generator set must be designed for a constant speed regulation because the generator is subjected to a severe fluctuating load during the manipulation of the telegraph key.

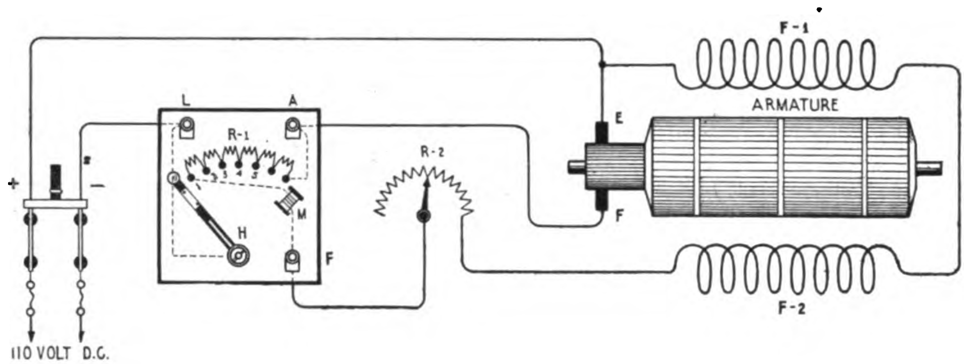


Figure 46

OBJECT OF THE DIAGRAM

To indicate the circuits and to show the use of a hand-operated motor starter (Cutler Hammer type).

PRINCIPLE

Because of the reduced counter electromotive force in a motor armature during the starting period, a resistance of variable value must be inserted in series with the circuit to keep the starting current at a safe value.

DESCRIPTION OF THE APPARATUS

The hand-starter has the binding posts, L, A, and F. The field coils of the motor are indicated at F-1 and F-2, and the armature brushes at E, F. A field regulating rheostat is indicated at R-2. A release magnet, M, is connected in series with the shunt winding of the motor. This holds the arm of the starter in the full running position.

OPERATION

To start the motor close the D.C. main-line switch. Draw the handle H, clockwise, slowly across contact studs, 1, 2, 3, 4, 5, etc. When the last point of contact is reached the magnet, M, grips the handle, H, holding it in this point so long as the current flows.

Should the circuit from the main line to the motor or the field circuit of the motor suddenly open, the magnet, M, will lose its magnetism, releasing the handle, H, which is thrown back to its original position by a spring mounted on the shaft.

QUES.—What precaution must be taken in starting a motor with a hand-starter?

Ans.—The starting arm should not be drawn over too rapidly or too slowly; if too rapidly, the motor armature may be burned out or the fuses blown. If too slowly, the starting resistances mounted within the box may be burned out.

QUES.—How can the proper acceleration of the starting handle be gauged?

Ans.—Generally, experience enables the operator to determine the proper speed of acceleration. This varies with different types of motors and the load to which the motor is subjected at the start. The average motor employed in wireless telegraph work for driving generators should not require more than twenty seconds for starting.

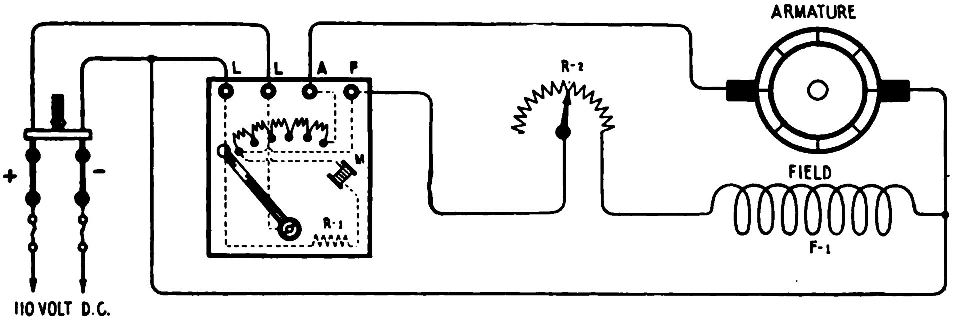


Figure 47

OBJECT OF THE DIAGRAM

To indicate the general circuits of the General Electric Company's hand-operated motor starter connected to a shunt wound motor.

DESCRIPTION OF THE DIAGRAM

The starter has four binding posts, L, L, A, F. The release magnet, M, is connected in shunt to the main D.C. line with the resistance coil, R-1, connected in series to reduce the flow of current.

OPERATION

The handle of the starter is drawn clockwise, as in the case of the Cutler Hammer type, being slowly moved across the contact studs until the arm is gripped by the magnet, M.

SPECIAL REMARKS

(1) If current from the power mains is turned off, the release magnet, M, loses its magnetism, releasing the starting handle which returns to its original position. The circuit to the motor armature is thus broken.

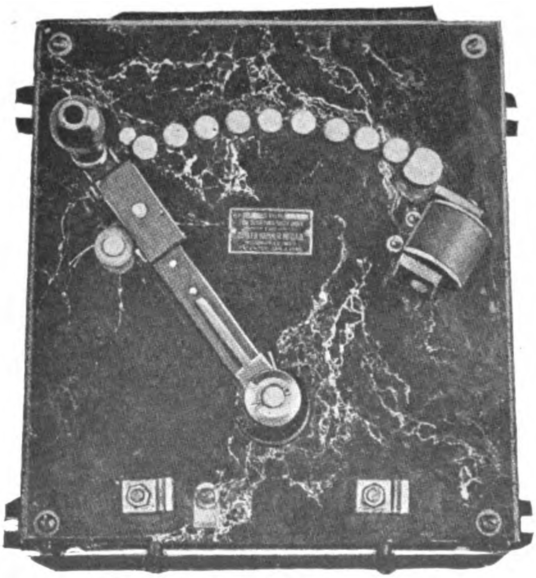


Figure 48.—Showing the general construction of the Cutler Hammer hand motor starter. The main resistance coils are mounted on porcelain spools and embedded in a heat-proof insulating cement. These are placed within the box. Taps are brought from the coils at regular intervals and connected to the studs on the front of the starter. The starting handle is held in the zero position by a spring in the shaft and in the full running position by the small release magnet at the right

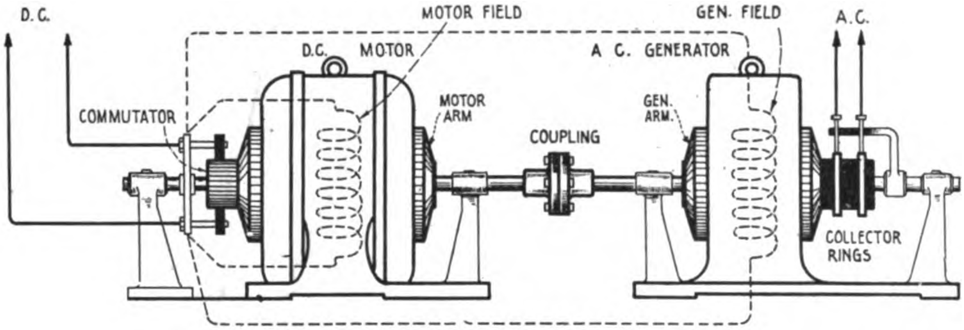


Figure 49

OBJECT OF THE DIAGRAM

To outline the general construction of a motor-generator for the production of alternating current at frequencies suitable for radiotelegraphy.

PRINCIPLE

If a source of direct current only is available and an alternating current is desired, a direct current motor can be connected to a source of direct current and made to drive an alternating current generator of any frequency required. By the insertion of field rheostats in the motor and generator field circuits, both the voltage and the frequency can be carefully regulated.

DESCRIPTION OF THE SKETCH

A simple shunt wound direct current motor is mechanically coupled to a simple alternating current generator.

OPERATION

When normal voltage is applied to the main D.C. terminals of the motor, an alternating current can be collected from the collector rings of the generator.

SPECIAL REMARKS

(1) The frequency of the generator can be altered within reasonable limits by increasing or decreasing the speed of the driving motor. The alternating current voltage may be increased by an increase of motor speed, or if the speed remains constant, by an increase in the field current.

(2) Generators for radio telegraph communication by spark discharge methods are designed for frequencies from 60 to 500 cycles per second.

(3) The motors of motor-generators for commercial ship installations are generally designed for connection to 110 volts D. C., but in certain special cases 65-volt motors are in use.

The generators are generally designed to deliver voltages varying from 110 to 500 volts. Some are designed with special characteristics, namely, a certain amount of magnetic leakage takes place under load which causes a sudden drop in voltage. A machine of this kind assists in quenching the spark discharge of a wireless transmitter.

(4) Motor-generators operate at speeds of from 1,800 to 2,400 revolutions per minute according to their design.

(5) Some types have four bearings and others have two bearings, the shaft being strengthened at the center to withstand the peripheral strain.

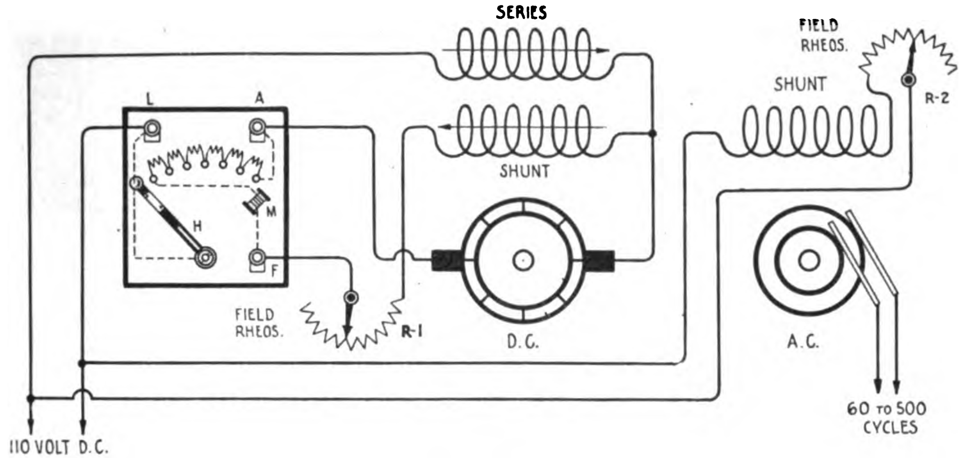


Figure 50

OBJECT OF THE DIAGRAM

To show the circuits of a motor-generator connected to a Cutler Hammer hand starter.

DESCRIPTION OF THE APPARATUS

The motor has a series field winding connected in series with the armature to the main D.C. line, and a shunt winding shunted across the armature terminals. The starter is of the type previously described. The motor speed regulating rheostat R-1 is connected in series with the shunt field of the motor and a second rheostat R-2 in series with the shunt field of the generator. The generator fields obtain their current from the same source as the motor.

OPERATION

The motor is started in the same general way as with the type previously described. The frequency of the generator can be increased by increase of resistance at R-1. The voltage of the generator can be increased by reduction of resistance at R-2 or decreased by the addition of resistance at R-2.

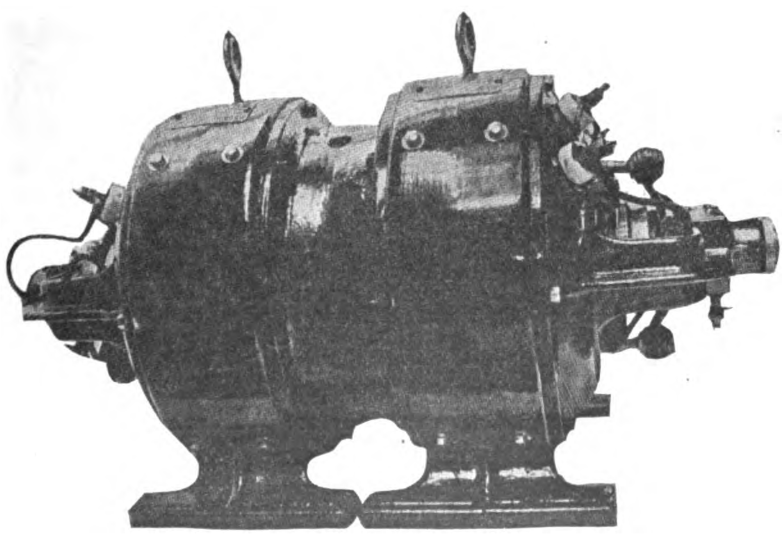


Figure 52.—Showing a 1 K.W. 60 cycle motor-generator of the Robbins & Meyers type. A simple shunt wound motor is directly coupled to a 60 cycle alternating current generator. This is a two bearing unit, the armature being strengthened at the center to withstand the strain. The bearings are of the self-oiling type and the generator has a special series winding (in addition to the shunt winding) which is connected in series with the motor armature. By means of this connection a practically uniform voltage is maintained at the generator terminals under fluctuating loads

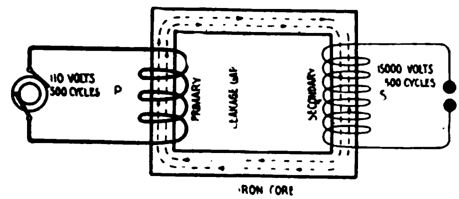


Figure 52

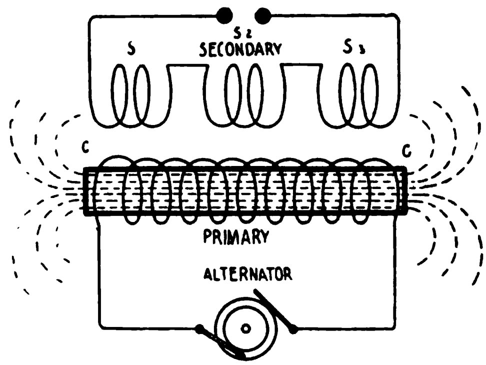


Figure 53

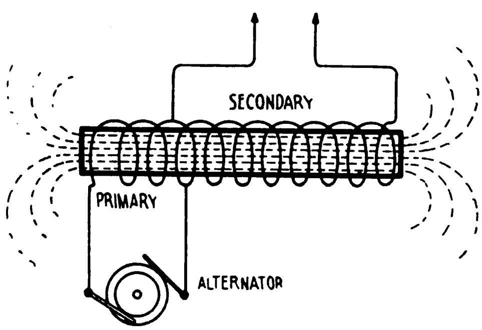


Figure 54

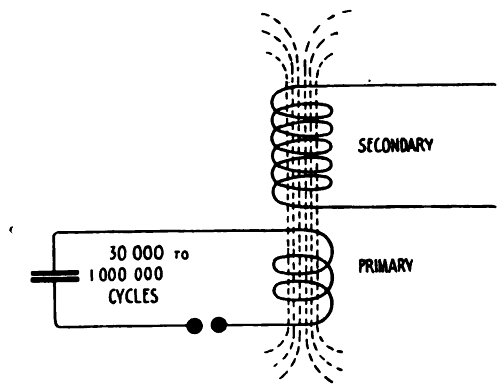


Figure 55

OBJECT OF THE DIAGRAMS

(1) To show how electrical energy may be transferred from one circuit to another by electromagnetic induction.

(2) To outline the apparatus whereby an alternating current of low voltage may be raised to one of high voltage or vice versa.

(3) Figure 52. To outline the construction of a closed core step-up voltage transformer.

(4) Figure 53. To outline the construction of a step-up voltage open-core transformer.

(5) Figure 54. To outline the construction of a step-up voltage auto-transformer.

(6) Figure 55. To outline the construction of an air-core radio frequency transformer.

PRINCIPLE

By placing a coil of wire in inductive relation to a second coil through which an alternating current is flowing, the magnetic flux generated in the latter coil will act upon the former and induce a current in it (provided the circuit is closed). By properly proportioning the ratio of turn in the two coils, the E.M.F. of the current may thus be increased or decreased.

DESCRIPTION OF THE DIAGRAMS

In Figure 52 the primary winding, P, and the secondary winding, S, are wound on a rectangular iron frame.

Winding P has a few turns of comparatively coarse wire such as No. 10 B. & S., but winding S may have several turns of fine copper wire such as No. 32 B. & S.

The iron core is laminated, i.e., it is built up of a number of sheets of soft iron, each piece of which is insulated from the neighboring piece (coated with shellac). This prevents the induction of current in the iron core which would occasion energy losses, but does not hinder the passage of the magnetic lines of force.

In Figure 53 the primary and secondary coils of the transformer are wound on a straight iron core which may be made of a bundle of fine iron wires or long strips of iron.

As a matter of protection (to prevent the breakdown of the insulation between layers) the secondary winding is often split into sections such as S-1, S-2, and S-3. (The primary winding is shown connected to the terminals of an alternating current dynamo.)

In Figure 54 a single coil performs the function of both the primary and secondary windings. This coil is wound on a straight iron core, a portion of the turns acting as the primary and the remainder as the secondary. Although a step-up ratio of turns is shown in the diagram, this type is more often employed as a step-down transformer, for example, to convert 110 volts A.C. to 6 to 15 volts A.C.

In Figure 55 the primary winding comprises a few turns of heavy copper tubing or heavy copper strip; the secondary may have a greater or lesser number of turns of approximately the same diameter.

OPERATION

If the primary winding of either of the foregoing types of transformer is connected to a source of alternating current, the flux generated thereby cuts through the secondary winding, inducing in it a current of similar frequency but of greater or less voltage according to design.

The strength and direction of flow of this flux, of course, follow the alterations of the primary current, rising, falling and reversing therewith.

SPECIAL REMARKS

(1) The transformer of Figure 52, if employed in connection with radio transmitting apparatus, is generally designed to produce secondary voltages up to 15,000 volts or greater. This high voltage current charges a condenser which, upon discharge, generates what are termed **radio frequency oscillations.**

(2) The open-core transformer of Figure 53 is also employed for the production of high secondary voltages of the order of 10,000 to 50,000 volts, and is employed for the same purpose as the transformer of Figure 52. By proper design it can be made as efficient as the closed core transformer, but it is more expensive to construct.

(3) The auto-transformer of Figure 54 is shown as having a step-up ratio of turns, but it is more often employed as a step-down transformer to produce in the secondary an E.M.F. of from 6 to 15 volts when the primary is connected to a 110-volt source of current supply. This type of transformer is frequently employed in radio receiving apparatus, but when used in this way it is not provided with an iron core.

(4) The radio frequency transformer of Figure 55 is employed in the high frequency circuits of the spark discharge type of radio telegraph transmitters to transfer extremely high frequency alternating currents from the generating circuit to the aerial wires where the energy is radiated in the form of electromagnetic waves. It is also employed in the receiving apparatus of wireless telegraphy but for radio-frequency work it is not provided with an iron core.

(5) The transformers of Figures 52 and 53 for purposes of wireless telegraphy are designed so that the **primary current remains practically constant** when the secondary is placed on short circuit. This is a natural inherent characteristic of the open core transformer, but to obtain the same effect with the closed core transformer of Figure 52, a magnetic leakage gap must be provided to prevent the reaction of the secondary circuit upon the primary circuit.

(6) The radio frequency transformer of Figure 55, if used in the transmitting circuits of a radio telegraph set, must have its primary and secondary turns well insulated by means of porcelain or any of the well known insulating materials. Owing to what is known as the "skin effect" of high frequency currents, a hollow conductor will possess the same current carrying capacity as a solid conductor. These coils, therefore, if not made of copper strip, are generally constructed of copper tubing. Owing to the phenomena of electrical resonance (to be explained further on) a step-up ratio of turns in this type does not necessarily indicate a step-up voltage.

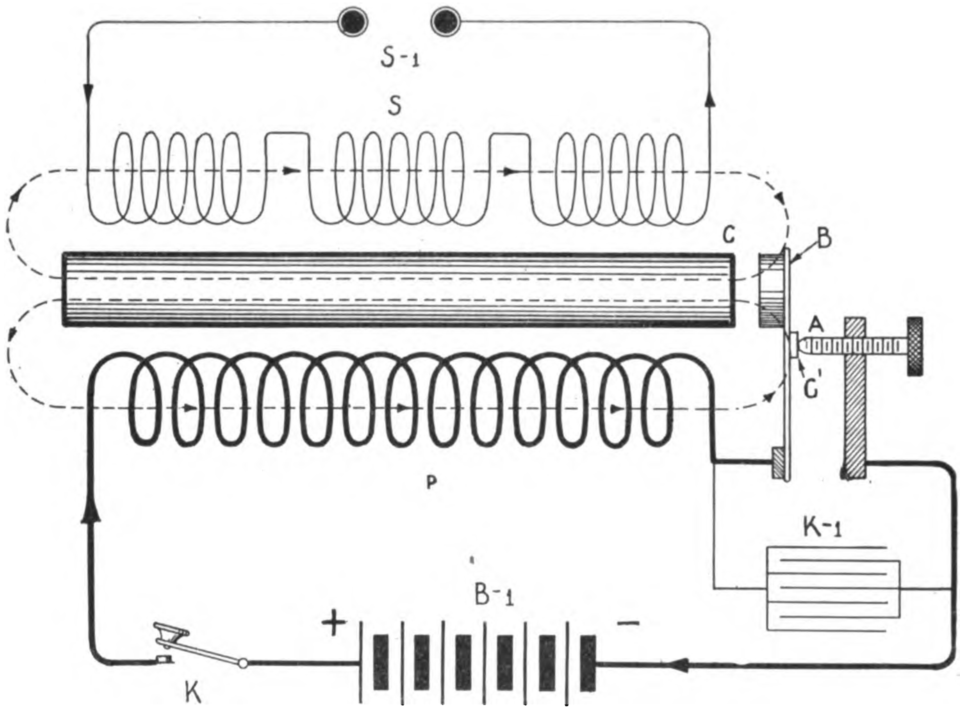


Figure 56

OBJECT OF THE DIAGRAM

(1) To show how a low voltage direct current may be transformed into a high voltage alternating current.
(2). To indicate the fundamental construction of the induction coil.

PRINCIPLE

If a number of turns of wire are wound about an iron core and connected in series with a battery, and further, a second coil of a considerable number of turns wound about the first coil, then if the circuit of the first coil is broken an E.M.F. will be induced in the second coil.

DESCRIPTION OF THE APPARATUS

The induction coil of Figure 56 consists of the iron core, C, the primary winding, P, the secondary winding, S, and the spark gap, S-1. The battery circuit is opened and closed by the key, K, and is automatically interrupted by a magnetic interrupter or vibrator mounted on the end of the shaft. This consists of the soft iron button, B, mounted on a phosphor bronze strip to which is attached also a platinum point, C-1. The stationary contact, A, also is fitted with a platinum point. The interrupter is bridged by a condenser of high capacity, K-1.

OPERATION

If the key, K, is closed and the stationary platinum point is screwed up until it makes contact with C-1, the circuit of the primary winding, P, is closed and the iron core, C, becomes magnetized. This attracts the soft iron button, B, which opens the circuit at C-1 whereupon the magnetic lines of force, generated by the primary winding, collapse. The vibrator spring is then released and C-1 again makes contact with the stationary contact, A. This process is repeated from 50 to 100 times per second, depending upon the over-all design of the apparatus.

If winding S consists of a great number of turns of very fine wire the E.M.F. generated in the secondary winding will be sufficient to break down the gap at S-1, even if the sparking points are separated several inches.

SPECIAL REMARKS

(1) Although the induction coil can be employed to generate high voltages it possesses a distinct disadvantage compared to the alternating current transformer. The amount of power that can be handled efficiently by the magnetic vibrator is limited to about 1 K.W. Furthermore, the wave form of the secondary current is such that it practically amounts to a uni-directional current, i.e., the current pulses induced in the secondary have much greater amplitude in one direction than in the opposite direction.

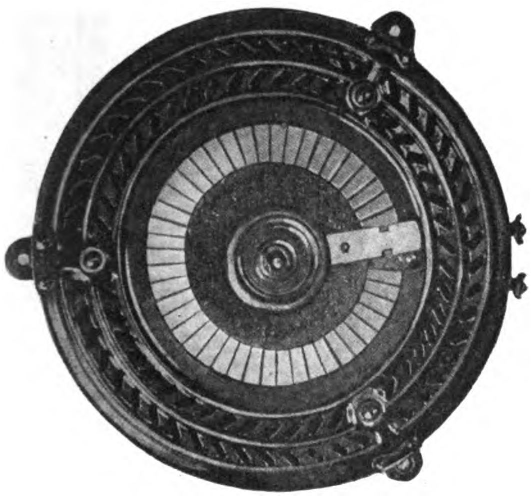


Figure 57.—Showing the general appearance of the Cutler Hammer type of field rheostat for regulating the field current of a dynamo or motor. The rheostat is made up of composition resistance wire baked in a heat-proof insulating cement and mounted in a metal case. The wire is tapped at intervals and leads are attached to brass studs over which a sliding contact moves

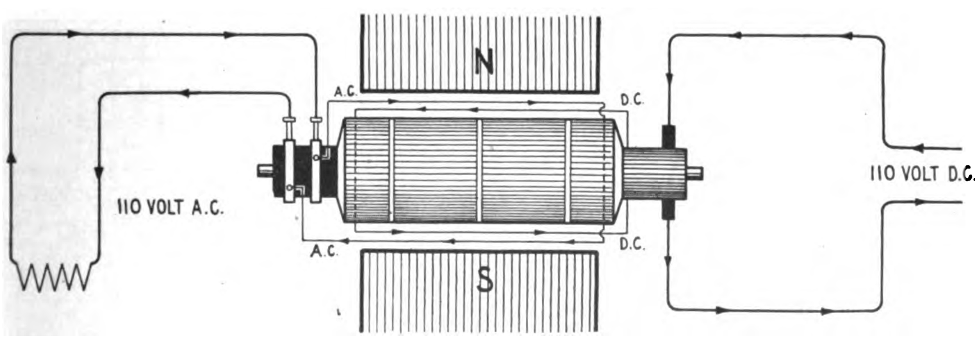


Figure 58.—Showing the complete circuits of the dynamotor for the conversion of direct current into alternating current. In this machine a single armature possesses two distinct windings one of which generates alternating current at the frequency for which the machine is designed, and the other acts as an ordinary motor armature winding. If direct current at 110 volts is fed to the motor winding, by proper design the generator winding can be made to generate an E. M. F. of any voltage required. These machines are not widely used in commercial radio telegraph installations and are desirable only on account of their simplicity, the principal disadvantage being that the frequency and voltage cannot be controlled as closely as with the motor-generator

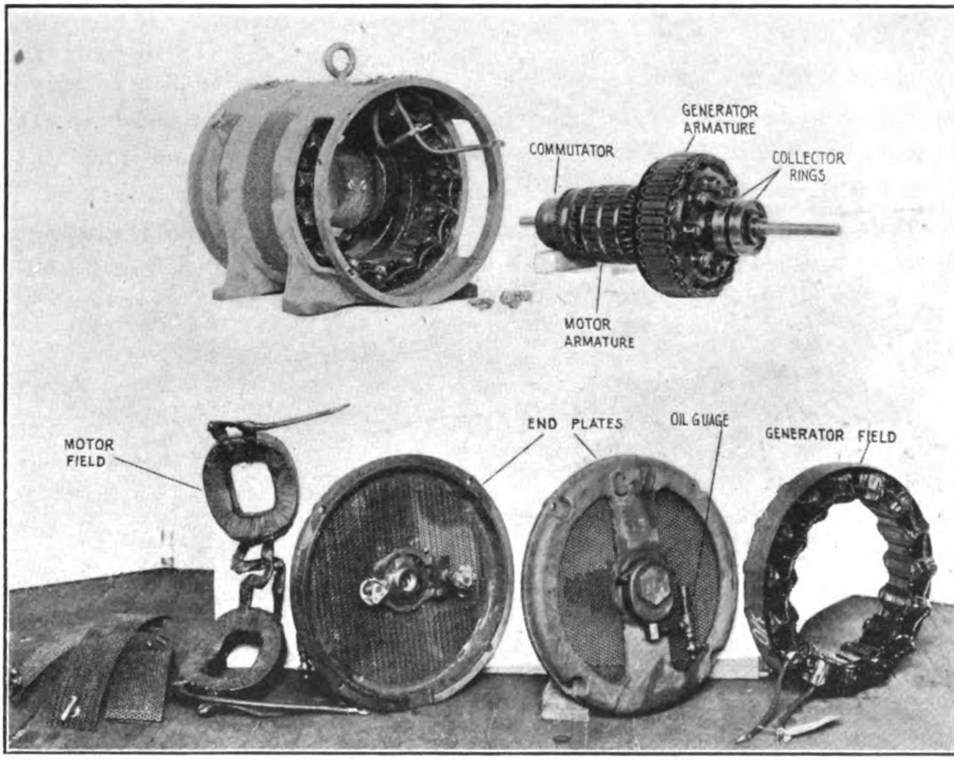


Figure 59.—Showing the general details of the Crocker Wheeler 2 K. W. 500 cycle motor-generator of the type used in modern Marconi radio sets. A two-pole direct current motor, taking current at 110 volts' pressure, drives a 2 K.W. 500 cycle alternating current generator. The armature revolves at 2,000 R.P.M. and the alternator delivers current on open circuit at an E.M.F. of 380 volts. When the armature circuit is closed the voltage drops to approximately 120 volts. The motor is designed to operate at a constant speed on D.C. voltages varying from 95 to 115 volts

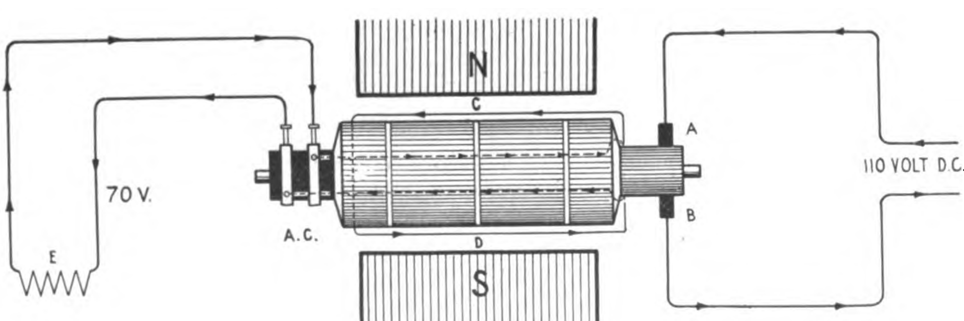


Figure 60.—Showing the general circuits of a rotary converter in which a single winding sets the armature into rotation and also generates alternating current which is collected by the collector rings on the left hand end of the shaft. If 110 volts D. C. are supplied to the motor brushes approximately 70 volts alternating current can be taken off the collector rings. If a higher voltage is desired, a small step-up transformer must be inserted at the point, E

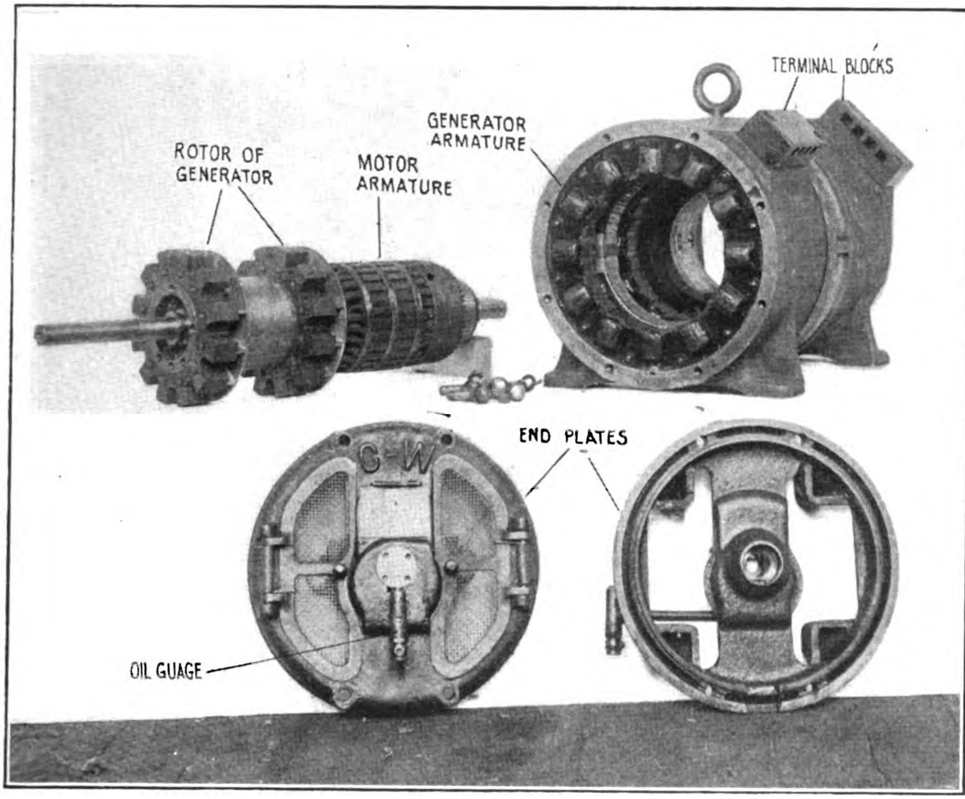
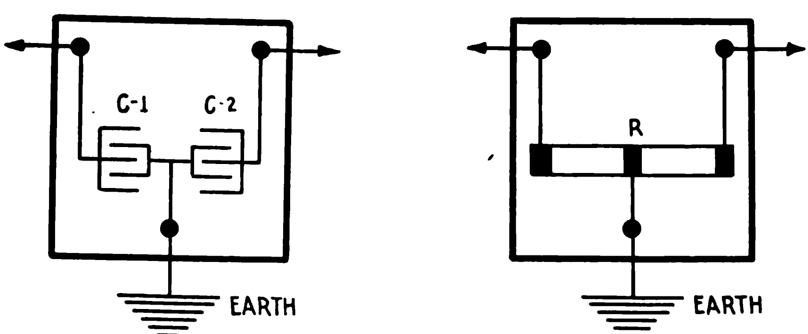


Figure 61.—Showing the general details and construction of a Crocker Wheeler ½ K. W. 500 cycle motor-generator as supplied with modern Marconi radio sets. Both the field poles and armature of the generator are stationary, the rotor being constructed of a toothed mass of iron which alternately opens and closes the magnetic circuit between the field poles and the armature coils. This machine has the same general operating characteristics as the 2 K.W. 500 cycle machine



Figures 62 and 63.—These drawings show protective condensers and a protective resistance rod, either of which may be attached to the circuits of the motor-generator to prevent burning out of the windings by electrostatic induction from the transmitting apparatus. Powerful magnetic and static fields are set up in the immediate vicinity of a radio transmitter aerial during the process of radiation, which may induce rather high voltages in the power circuits. With either of these devices the differences of potential between the windings and the frame are neutralized and the induced current is diverted to earth. The condensers generally have capacity of one microfarad each. The rod has resistance of 1,000 ohms

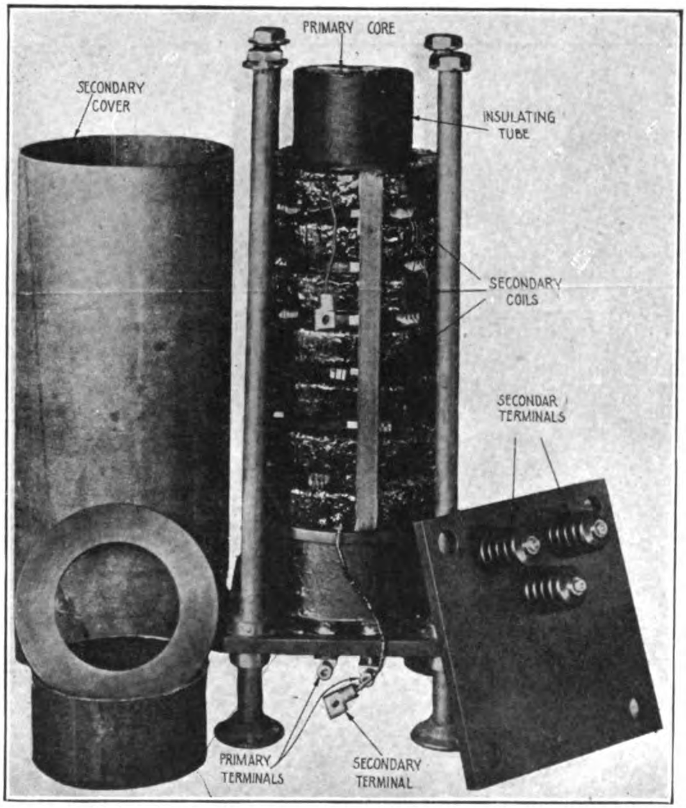


Figure 64.—Showing the general construction of the 2 K. W. 500 cycle open core transformer as developed by the American Marconi Company. The primary winding consists of a single layer of wire wound over a soft iron core made of iron strips. The secondary winding is composed of a number of sections of comparatively fine wire which are connected in series and slipped over an insulating tube placed about the primary winding. The secondary terminals are connected to a lid on the top of the transformer and are specially insulated therefrom. The primary terminals are attached to the binding posts at the base. Dry insulation is employed throughout.

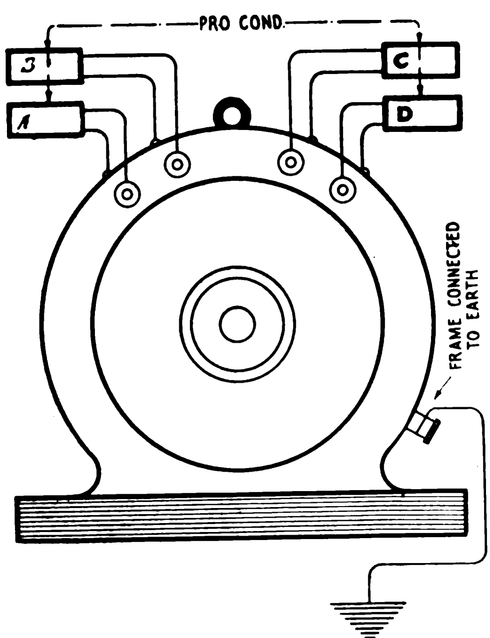


Figure 65.—Showing how protective condensers are connected to the frame of modern motor-generator sets. One terminal of condensers, A, B, C, and D is attached to the binding posts of the motor-generator, and the remaining terminals to the frame. The frame in turn is connected directly to earth. These protective condensers are shunted across the field winding and across the A. C. and D. C. armatures of a motor-generator

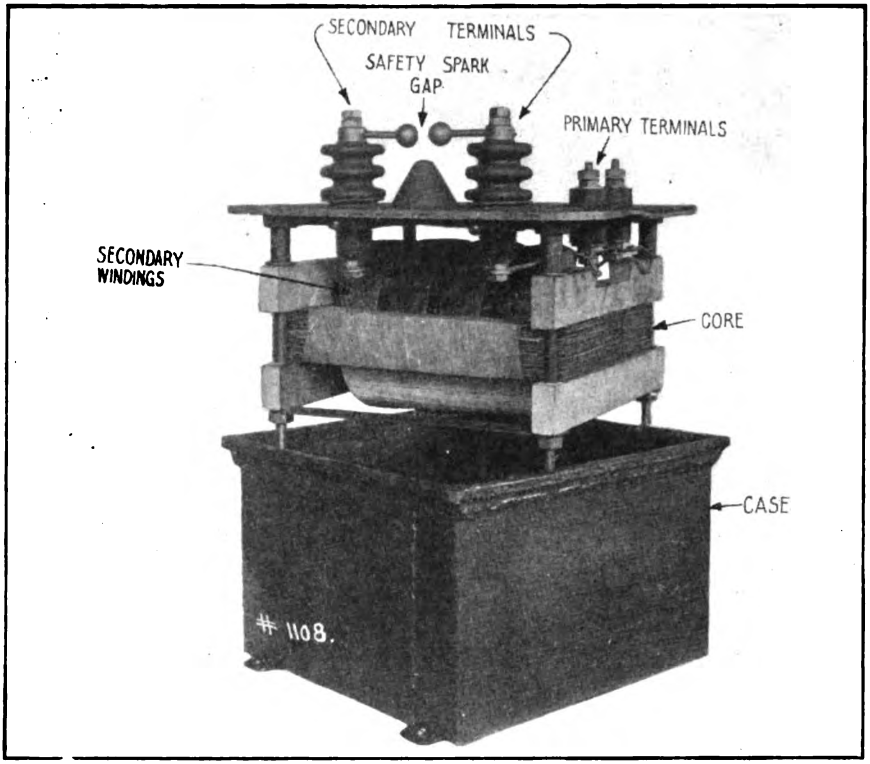


Figure 66.—Showing the construction of the Marconi 2 K.W. 500 cycle closed core transformer. The primary and secondary windings are wound on a special leg inside a rectangular iron frame. The transformer takes current at a pressure of 120 volts at the primary and delivers current at pressure of 12,500 volts at the secondary. The core is mounted on wooden blocks and the entire core and coils are immersed in a semi-liquid grease in a metal container. A safety gap is provided to prevent break-down of the secondard windings under special strain. Both this transformer and the one shown in Figure 64 are specially designed for Marconi quenched spark transmitters

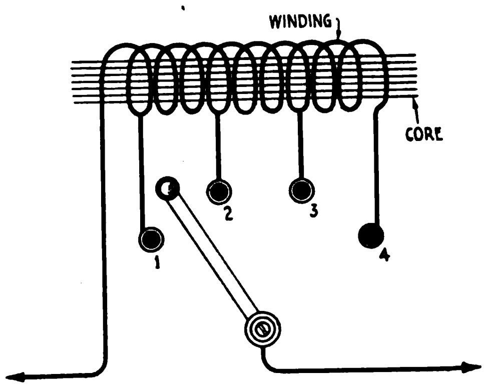
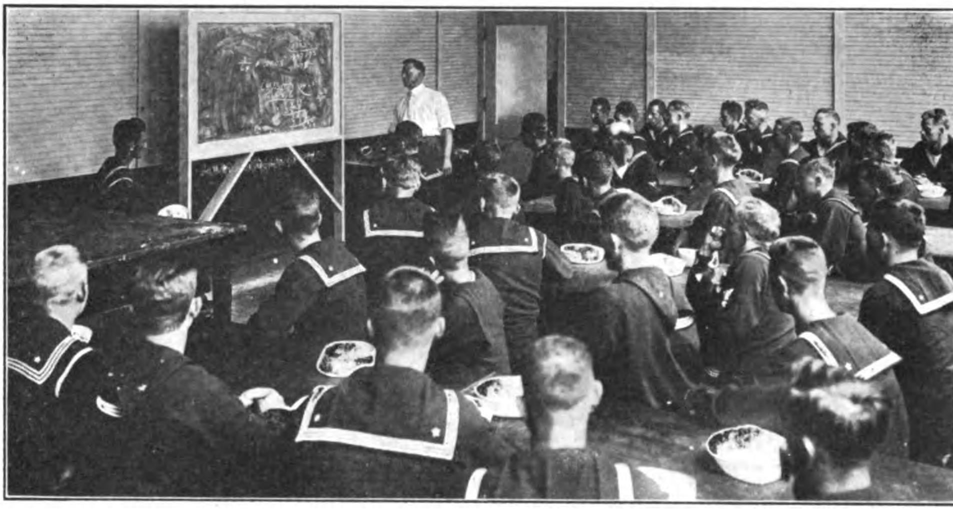


Figure 67.—Indicating the general circuits of a primary reactance coil which is connected in series with the primary windings of a transformer. This coil may be used to regulate the flow of alternating current or to place the primary and secondary circuits of a high voltage transformer in electrical resonance. The reactance of the coil can be varied in two ways—either by drawing in and out the iron core, or by placing the contact blade of the switch on the successive taps 1, 2, 3 and 4, as shown

(To be continued)



Dunwoody apprentices undergoing an oral examination

Teaching Wireless to Bluejackets in the Northwest

The Expansion of Radio Training at Dunwoody Naval Station in Minnesota

By WILLARD CONNELY, U. S. N. R. F.

"IMMEDIATE necessity for more electricians-radio," read a message recently sent by the United States Bureau of Navigation to Ensign Colby Dodge, U. S. N., commanding officer of the Dunwoody Naval Training School in Minneapolis.

Coincident with this message was issued an illuminating announcement by commander E. L. Bennett, assistant chief of the bureau. It was to the effect that the Navy Department contemplated assuming control of all the ships of the American Merchant Marine, and operating them with naval officers and enlisted men.

The intelligence of the wireless operators must be second to none. Among bluejackets high school graduates are in the minority in the ranks of the enlisted men, and those with any college training naturally are still fewer. These two classes of men, with former telegraphers, make the most progressive students of wireless. Of course cases are found where men with meagre schooling but natural aptitude for the art become proficient. However, Uncle Sam's wireless recruits are chosen from the enlisted men with a care which is probably not exceeded in any other branch of the service. When the fact is taken into consideration that some of the first line battleships in our constantly augmented Navy each require no less than thirty radio men, the extent of the task in training them can be realized, particularly as the extra burden of providing operators for the merchant ships now has to be taken into account.

So the Dunwoody Station, as the only naval school in the Northwest teaching

wireless, found it necessary to increase without delay its quota of radio students. Captain William A. Moffett, U. S. N., commandant of the midwestern naval district with headquarters at Great Lakes, Ill., and Ensign Dodge hastened this expansion.

The sailors came to Dunwoody, 450 strong, early last August, just after the acceptance of the offer of the Dunwoody Institute, free, as Government quarters for the bluejackets' instruction. Nine groups of fifty men each were to learn nine different handicrafts in a four months' course of study and application. There were classes in gas-engineering, coppersmithing, blacksmithing, general electricity, cooking, baking, carpentry and machine-shop work in addition to those in wireless.

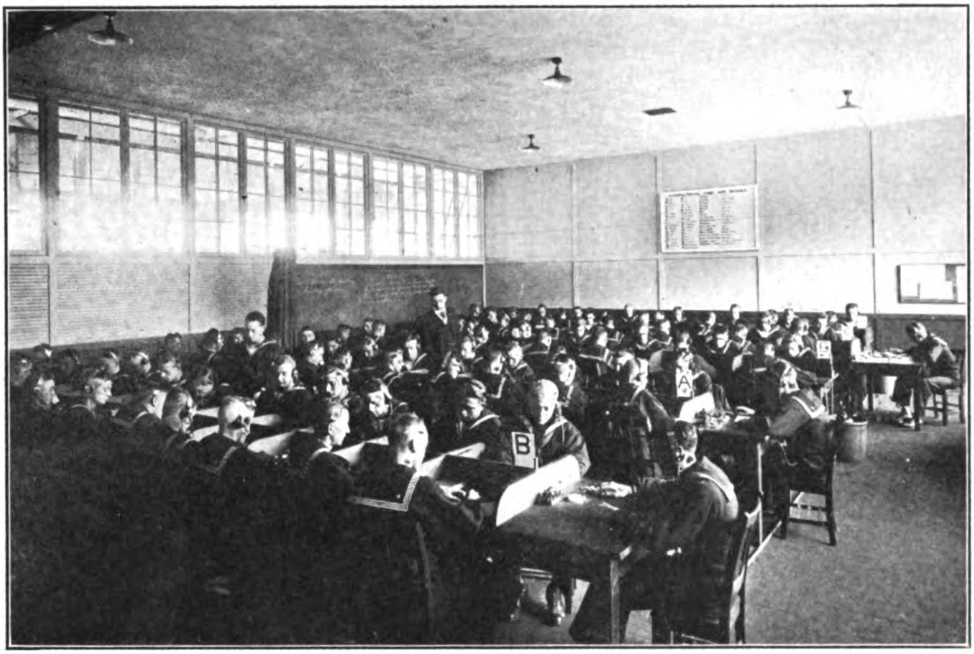
The fifty radio students then at Dunwoody Station had come from the Mare Island Navy Yard in California, where they had already undergone considerable experience in wireless. With the advantage of the additional instruction in Minne-

Wireless students at the general mess. On the left is shown Miss Anna Stanley, chief commissary steward

apolis these men became able to receive from fifteen to twenty-five words a minute, international code. Two of the men, Ross and Strachan, were copying more than thirty words. Accordingly the Bureau directed that the Mare Island contingent be transferred to the Government Radio School at Harvard University in order to receive final instruction before going to sea. Permission was granted to retain Ross and Strachan at Dunwoody as assistant instructors.

Then came from Captain Moffett's colony at Great Lakes a class of fifty, most of them new in radio, to replace the Mare Island students. These were followed in a few days by fifty more picked men, and before another week had elapsed a detachment of one hundred, as carefully chosen, arrived at Dunwoody.

Dunwoody has for the head of its radio department W. R. Davis, formerly chief electrician-radio on the U.S.S. Birmingham. When the Bureau of Navigation decreed that the wireless detachment be made the largest and most consequential at the Dunwoody Station, five more assistant instructors from the Harvard Station were detailed to aid Mr. Davis. These instructors, P. W. Ablondi,



Members of the radio class sending and receiving. Standing in the center is Instructor W. R. Davis, formerly chief electrician-radio on the U. S. S. Birmingham

B. L. Barrett, F. C. Danforth, J. Lovejoy and C. R. Woodall, were assigned to teach code and related work with Ross and Strachan. All are enlisted bluejackets, with advanced ratings.

Mr. Davis has divided the apprentices into four sections. Three of his seven assistants are detailed to the operating room and the other four are in charge of the two recitation and lecture halls.

The wireless men have lodgings at a hotel near the Institute. Reveille is at half past five o'clock in the morning. At six o'clock the assistant instructors, acting in the coordinate capacity of section leaders, assemble the men for roll-call, then march to the training school. Breakfast is served an hour later, and the daily work begins at eight o'clock. For an hour and a half the first two sections occupy the operating room for code work. This period ended, each section proceeds to a recitation hall for related studies and lectures. Sections three and four, of course, reverse the program, while the three hours' work in the afternoon are divided in the same manner. At twenty minutes to four o'clock in the afternoon the men are at liberty. It has been observed, nevertheless, that the most promising students often use the latter end of the day (until the six o'clock evening mess) to write in their log books or daily records. Two hours of outside work and study are required daily.

As the course is now arranged, a sixteen weeks' schedule has been mapped out. During all the period except the final week, operating practice and the study of radio laws take up considerable of the time. But the related work is also of prime value. For example, in the first month the men attend recitations and lectures and work in the laboratory and machine shop, receiving instruction concerning magnetism and electricity, storage batteries and alternating and direct currents. During the second thirty days Mr. Davis has scheduled instruction concerning internal combustion engines, transformers and induction coils, radio power circuits, condensers and oscillating currents, theory of radio telegraph, antennae and ground.

He proceeds during the third month with instruction in oscillating circuits, spark discharges, transmitting sets, spark systems, arc systems, wave-meters and

measurements. At the end of this time the students go into the more advanced investigation of receiving circuits, receiving sets, vacuum valve hook-ups and operation, concluding with main station operation and care. The training ends in the final week with a comprehensive review and examination.

At the end of each week students are examined in sending and receiving, and are also given ten questions to answer concerning subjects taken up during that week. All students are marked weekly on four general counts: theory, practice, log book and conduct. A mark of 4. represents a perfect performance, with marks of fair and probation grading down to 2.39; the latter figure indicates inaptitude. A man displaying general deficiency is returned to the station or navy yard whence he came. From there he is usually dispatched to sea as an ordinary sailor. Such cases of failure are rare.

Promptness in keeping log books up to date is insisted upon. The book must contain a diary of deductions and compilations and sketches of instruments and materials used. Instructor Davis gives out each week a list of twenty questions to be answered in the log books, in addition to the transcription of individual notes mentioned. Questions answered in log books at the end of the fourth week of study in the Dunwoody radio classes follow:

1. How many ampere hours will be recorded by a meter through which 160 amperes have passed for three quarters of an hour?

2. Explain the difference between current strength and the quantity.

3. Which effects of the current are directly proportional to it?

4. What is the function of an insulator?

5. How does low conductivity affect insulating qualities?

6. What is the circular mil area of a wire three-sixteenth in diameter?

7. What is the square mil area of a No. 12 B & S copper wire?

8. The coils of a rheostat made of No. 8 iron wire have a resistance of ten ohms. What length of wire was required to construct this rheostat?

9. Draw a diagram of ten cells in series; also in parallel and series parallel.

10. State Ohm's law in full. How would you find resistance if E and I are known?

11. How do you find the joint resistance of unequal resistances in parallel?

12. Show a sketch of a wire carrying current marking the direction of the current, and the direction of the magnetic lines around the wire.

13. Draw a diagram showing an ammeter and voltmeter connected in circuit.

14. Explain exactly the difference between force and work.

15. What is the difference between a kilowatt and a kilowatt hour?

16. How many watts are expended in an arc lamp having a hot resistance of 4.5 ohms and requiring fifty volts?

17. How many kilowatts would a ten horse-power motor require?

18. A motor armature has a resistance of .001 ohm. How much current would flow through this armature if connected to a 220 volt supply and not allowed to rotate?

19. What would a voltmeter indicate if connected across a resistance of twenty-five ohms, and an ammeter in the circuit indicated ten amperes?

A special short course in wireless telegraphy will be offered men accepted for service in the Dunwoody Unit of the National Aerial Coast Patrol. Instruction in seaplane and torpedoplane flying is to be given on Lake Minnetonka, a few miles southwest of Minneapolis. Lieutenant-Commander John Towers of the Bureau of Operations, and Ensign Dodge of Dunwoody are now collaborating on details for this instruction. The radio course is being mapped out by Acting Director H. W. Kavel, who has general charge of the Dunwoody routine, and by Instructor Davis.

One result of the expansion of naval radio training at Dunwoody has been to increase the interest in wireless in the Northwest. Another has been to demonstrate the need for wireless operators in the Navy.

A Digest of Electrical Progress

The Relation of the Engineer to the Problems of the War and the Necessity for United Effort to End It—Accomplishments in Wire Telephony—The Use of Phantom Circuits for Increasing the Capacity of a Given Number of Lines—The Story of the Torpedo

THE ENGINEER AND THE WAR

IN a stirring inaugural address delivered before the American Institute of Electrical Engineers, E. W. Rice, Jr., President-elect, discussed the relation of the engineer to the problems of the present war He impressed upon his auditors the fact that modern warfare is wholly a problem of mechanics and engineering, and that the present conflict will only be brought to a successful termination by conducting operations along scientific lines.

Because its activities embrace all other fields of scientific progress, the speaker declared, the profession of electrical engineering is foremost among all other engineering professions. Hence, those engaged in electrical engineering were, in the present national crisis, called upon to offer a supreme sacrifice and nothing but organized and disciplined work would prove successful. Concerning this point he said:

> "No nation of loafers ever won the war. Other things being at all equal, that nation or people who are willing to work the hardest will surely win the victory. I wish to point out that the enemy we are fighting is recognized as the most industrious organization in the world. Our enemy has prepared for war for fifty years, and has been working with ever-increasing energy ever since the war was started three years ago. We made no adequate preparation during all this time, and therefore started with a fearful handicap of lost time and lost opportunities. We must not delude ourselves that our enemy is exhausted, but remember that he has the advantage of a full 'flying start.'
>
> "We must accelerate at an incredible rate if we are to get our war motor going fast enough, soon enough to catch up.
>
> "Our enemy boasts that we have started too late. We must, by the hardest work, directed with scientific skill and accuracy, organize and effectively utilize all our power of work to make his prophecy an idle boast."

It was remarked that we were called upon, as never before, to put aside personal preferences. No matter how repugnant war might be to our habits of thought, we must adopt those methods which the enemy has found to be most essential. Constructive criticism administered sparingly during this period would be helpful and would do far more than mere fault finding.

The popular mind, Mr. Rice pointed out, is apt to believe that this war will be settled by some wonderful and perchance miraculous invention, but engineers engaged in practical work realize how impractical and hopeless such a possibility is. No superman or hero would end this conflict. The united effort of thousands of men skilled in various professional lines, each contributing his bit, only would

avail. Team play in our civil army at home was as essential as in our fighting army abroad.

Continuing along these lines, the speaker said:

> "I venture to suggest that we cannot all occupy desks at Washington, and it is well for us and for the country that we cannot. We can, however, put ourselves and our business in such condition as to meet whatever demand is made upon us. Only relatively few can be useful in the direct service of the Army and Navy, but there is plenty of honorable work and useful work for us to do. The most effective work for most of us will be in the shops and offices at home, and everyone who does his work loyally and well is as much a factor in our organized war as the man at the front."

The problem of this war demanding an immediate solution, he asserted, is that of shipping, but it would be successfully solved if we were content to employ the simple common-sense methods used by engineers and successful business men in the ordinary course of business. It was merely a race between ship building and ship destruction. We must also adopt the very latest methods of loading and unloading vessels in order that there might be the least delay in port. Above all, we should build a vessel that would prove most adequate in defense against attacks of the submarine, no matter what the cost of the vessel might be or how impractical it might prove after the war. He pointed out that it was also well to take into consideration whether it was worth while to continue building large dreadnoughts, battle cruisers and the like, which cannot possibly be finished for years to come. Unless our ship-building facilities were limited, our efforts should be concentrated and spent in the construction of large, high-speed cargo ships which could be built in one-half the time. This would be a great step towards solving the problem.

Proper development of the submarine should also receive its full share of attention, for we might yet have to rely upon undersea craft to convoy our vessels through the war zone.

In this crisis the selfish theories of the individual must give place to compromise and all work should be actuated by a spirit of conciliation.

THE ADVANCE OF WIRE TELEPHONY IN THE UNITED STATES

THE average engineer does not fully realize the problems which telephone specialists have encountered in the establishment of transcontinental or local telephone service. The construction of such lines is not merely a matter of stringing wires from pole to pole; technical problems of the highest order are involved, says a recent issue of the *Sibley Journal.*

In the transmission of the human voice over a wire line a complex alternating current is employed at frequencies varying from 200 to 2,000 periods per second. This energy must not only be transmitted without distortion, but there must be sufficient energy delivered at the receiving station to operate the receiver. In addition, the telephone line must be fully protected from extraneous inductive disturbances such as may be set up by nearby power or lighting circuits.

Take, for instance, the wire telephone line from New York to San Francisco. This is 3,400 miles in length and contains about 3,000,000 pounds of copper, and while difficulties were encountered in establishing the poles and wires alone, the greater problem was one of delivering sufficient energy at the receiving station to give audible response in the receiver. It is an established engineering fact that

1/1000 part of the energy put in at the transmitter must be delivered to the receiver in order to obtain successful operation, but a transcontinental line such as that mentioned would actually only deliver about 1/50,000,000,000 of the energy put in at the transmitting end unless special appliance were provided.

The first step employed to overcome the line losses of lengthy circuits was the insertion of loading coils placed every eight miles through the entire circuit. By the use of these coils the energy at the receiver was increased from 1/50,000,-000,000 to about 1/1,000,000 of the energy put in at the transmitter. In order that the loss from the loading coils themselves might not attain in the aggregate an extremely large value, the design had to be very carefully calculated.

Considerable amplification of the strength of telephonic signals has been obtained by the use of electronic relays which control the current of a comparatively high voltage battery and thus amplify the signals. Telephony by means of cables over great distances has always presented a difficult problem. Great losses are occasioned by the fact that the dielectric, in order to separate the conductors underground, is other than air.

The Bell telephone system has established an underground cable between Washington and Boston, practically 500 miles in length, which required very careful calculation of the loading coils to reduce the line losses to a minimum. Without the loading coils only 1/30,000,000,000,000 of the energy sent out would be delivered at the receiver, but by extremely careful designs of the loading inductances this loss was reduced to 1/300 of the transmitted energy. A number of step-up amplifiers of the electronic type, added at proper points along the line, delivered one-tenth of the energy at the receiver, which resulted in a telephonic service of a very high order.

An interesting aspect of the transmission of telephone currents over long distances was the fact that in reality electric wave propagation is dealt with and that the length of such waves for a frequency of 800 per second is about thirteen miles. In considering this fact more in detail, it becomes evident that the receiver produces practically no reactive effect upon the transmitter.

Another ingenious adaptation of telephone lines has been the use of phantom circuits for increasing the capacity of a given number of lines. Two wires of one metallic circuit and two wires of another metallic circuit are used in pairs as one side of a given system and by gaining perfect balance, a third circuit is provided for commercial use. Each wire of a given metallic circuit also has been employed, by proper connection to earth, as one side of a telegraphic system, telephone conversation being carried on at the same time.

Power and lighting systems which may happen to be in inductive relation to telephone circuits are among the greatest sources of inductive noises. Usually, in the case of an alternating current circuit, it is found that it is not the fundamental frequency which interferes, but one of the upper harmonics.

It has been proposed in Europe to overcome the limitations of long distance wire telephony by the use of large powers at the transmitter, but experiments made by American engineers have determined that no advantage would be thus gained. As a matter of fact, a distinct disadvantage would result, and it is agreed that the present type of transmitter and receiver with properly associated apparatus fulfills all requirements.

THE TORPEDO'S STORY SELF TOLD

IT is seldom that we have a heart to heart talk with a modern torpedo. The average layman's knowledge of this destructive instrument of warfare is confined to the fact that it is self-propelled, can travel through the water at a fair rate of speed and work destruction to a million dollar cargo in a fraction of a minute.

The phantom torpedoes of conversation that can do better than sixty miles an hour; that can travel more than fifty miles in a single trip; that can cross the ocean if necessary, and are controlled in their paths by electricity or magnetism—these are set at nought in a tale told by a torpedo to Gunner's Mate Freed in a recent issue of the *Popular Magazine.*

"I am twenty-one feet in length and twenty-one inches in diameter, and ordinarily I am assembled in three parts known as the tail and after-body, the flask and the head. My tail contains the machinery which turns the propellers that force me through the water; the flask carries my fuel in the form of compressed air that sends me on my mission of destruction. I cost nine thousand dollars, and can run for ten thousand yards, or more than five miles, before my energy is used up, traveling that distance at the rate of about fifty feet per second. I am a monster made of forged nickel steel, and weigh two thousand pounds and have turbine engines which are capable of making one thousand seven hundred and sixty revolutions per minute. In my head I carry a high explosive called guncotton, which explodes upon contact. In times of peace, when I am practiced with, the guncotton is taken out of my head, and water is substituted to compensate for its weight. When I have been fired in practice, and have made my run and expended all my energy, I have lost sufficient weight to float to the surface until I am picked up, recharged, and refired."

So much for the general construction. It seems, however, that the initial trial trip of the autobiographical torpedo did not prove successful, for it is remarked that a drain plug came out of the air flask, which caused the torpedo to fill with water, sinking it to the bottom. A diver was soon detailed to locate it.

After recovery, the torpedo was once more placed in its cradle, and having been fully charged with air, was without delay again fired at a target located at a distance of 10,000 yards. A perfect hit was scored. The history of the torpedo continues:

"As I passed from the tube my starting lever was automatically thrown to the rear, thereby lifting a valve off its seat, allowing my compressed air—which previously had been packed away in my air flask—to escape through my tail, and thereby causing my machinery to run at terrific speed. As previously arranged by the naval gunners, I descended to a depth of eighteen feet, and then straightened out on my course. My course was followed as straight as a die for the whole run of ten thousand yards, not deviating two feet on either side. My machinery worked like a clock, and I knew that my run was being anxiously followed by the gunners, who were looking through binoculars from the deck of the submarine.

"At the completion of my run, I came to the surface, whereupon I discovered that I had been fired at a target at an eight-thousand-yard range, and that I had passed directly under the center of the target, making a perfect run, which is known as a 'bull's-eye.' I had a very short time to remain in the trough of the sea to wallow around, for, within a very few minutes, one of the navy's fifty-foot speed boats had caught up to me, and soon had me in tow back to the submarine."

Keeping the Governmental Eye on Amateur Stations

By a United States Radio Investigator

I SAT by a window in the Navy Yard, looking out upon the hustle and bustle that has marked Naval activities in this country since April 9th, when the Ensign summoned me.

"It is reported," he said, "that an operative radio station is located somewhere upstate, working only between one and two in the morning. Hurry home, change into plain clothes and meet Jackson in front of the Hotel Astor. He will have on a checked cap and will be in an automobile showing license number 378-174."

This was the order that sent me on an assignment which I anticipated would bring to light something else than the operations of a careless amateur. I met Jackson and we started. A slow drizzling rain set in, then we had tire trouble; so, by the time we arrived at our destination, we were in no mood to be lenient with an amateur disregarding the law, which calls for the closing and sealing of all private radio stations not engaged in Naval communication.

After locating the house, which had a hundred-foot aerial on the roof, we settled down to work. And we found—not a German spy; only a typewriter and an aerial with the leads disconnected.

A lodger, the proprietor of a restaurant, had been typing menus enough to last during the time he planned to be absent on a vacation. This accounted for the "crackling" that was heard at night. It is likely that the case would not have been reported if the aerial and masts had been down.

On another occasion I was ordered to investigate a supposed wireless plant on the roof of a three-story brownstone house in New York, dwellers nearby having spoken of "a German spy talking to the Kaiser through the air."

I visited the house, questioned several tenants, and then went to the roof. There I found an American flag floating from the top of a mast that supported an aerial, the leads of which were disconnected.

A son of one of the tenants, I learned, had installed a wireless plant before the entry of the United States into the world war. When that event occurred, the apparatus was disconnected and stored away in a trunk. The mast was left standing, however, and the aerial was never lowered. That was what started the investigation.

It is cases like these that subject the United States Radio Investigators to considerable annoyance and loss of time. Heedless amateurs use their receiving apparatus, after the aerial has been lowered, by connecting the leads to telephone wires, or by leaving up their aerial after disconnecting and storing the apparatus. Some lower their aerials and leave the apparatus set up on the operating table.

The Navy has been delegated to see that the President's orders for the confiscation of private radio apparatus are executed. The orders provide for the confiscation of such apparatus not sealed and stored away.

One costly set of apparatus was confiscated because the equipment was connected to a dummy antenna in a room. The owner, who had read suggestions

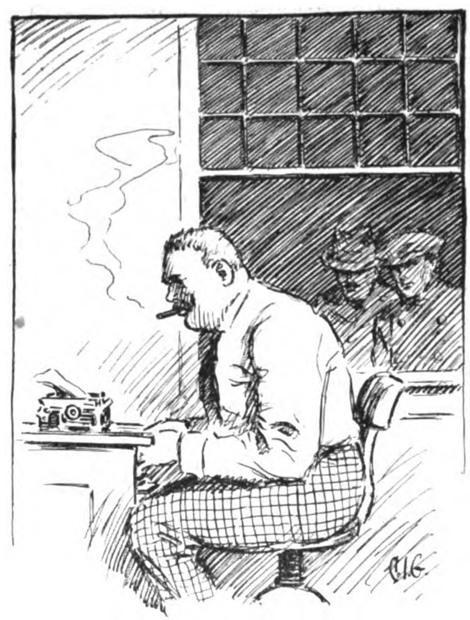
for improving the set by using a dummy antenna inside the house, carried on experiments which he believed did not violate the law, since no energy was radiated outside.

Amateur radio stations must be dismantled. Antennae must be lowered and masts razed. All apparatus must be disconnected, sealed and stored away. Experiments involving inductance and capacity and such power and voltage as would justify terming the tests "radio telegraphic experiments" are forbidden. No aerial must be used; ground connections must not be made. In short, all the experiments usually performed by amateurs must cease.

The Government, however, does not intend to forbid doctors using induction coils for taking X-ray pictures, or physical laboratories from performing conventional induction coil and transformer experiments.

It has been pointed out that the utilization of valuable amateur equipment and the services of amateurs throughout the country are pertinent subjects for Government consideration. But the Navy has installed its own system of espionage for detecting possible operations of agents of the German Government in the United States; therefore it behooves the amateur not to retard the actual work of locating German wireless agents by causing complaints to be lodged regarding masts and aerials. Every amateur club should make sure that the President's orders are observed.

Amateurs would do well also to keep in mind the fact that now, when their stations are silenced, is an excellent time to learn the American Morse code, for good operators should know both codes. In order to secure a Commercial Extra First Grade License, for instance, one must know the American Morse. Landline telegraphy is a particularly promising field for women or for amateurs who cannot pass the physical examination necessary for enrollment in the Naval Reserve Force.



A lodger, the proprietor of a restaurant, had been typing menus

A CALL FOR TECHNICAL MEN TO SERVE AT HOME

The attention of wireless men is called to the need of men whose ages range from eighteen to forty in sundry branches of technical troops in the United States Army. Technical men who are exempt or who for any reason cannot volunteer, can yet efficiently co-operate by forming technical patriotic guilds in their several industries or home neighborhoods to look after the welfare of the men in the service and give them the opportunity of obtaining technical assistance, opinions and advice. Men skilled in any line of science, mechanical, electrical or chemical, or in building aeroplanes or ships, are wanted as technical guildsmen. Applications for literature should be made to Major J. E. Bloom, U. S. A., 266 Market Street, Newark, N. J.

Amateur Department

A Night Signaling System

By F. E. AUSTIN

ALL methods of signaling may at present be divided into two classes, audible and visual, and the visual may also properly be separated into two classes, night and day signaling. Night signaling is performed by the operations of a single light or by the simultaneous operation of several lights. When a single light is employed, it is flashed on, and rendered invisible by operating a shutter; or if an incandescent electric lamp is employed, the circuit is opened and closed by means of a switch.

If several lamps are to be operated simultaneously, the operation can best be effected by means of switches or keys. A simple system designed for signaling a distance of three or four miles at night, using the normal unaided eye, or a distance of ten or more miles, using field glasses, will be outlined.

The apparatus consists of four white and four green incandescent lamps, arranged as shown in the accompanying drawing on a pine board about 16 feet in length and not more than 3 inches in width. The shaded circles denote the green lamps and the unshaded circles denote the clear bulbs or white lights. Tungsten filament lamps may be used, 40 watt lamps being satisfactory. The lamps may be designed for 110 volts, 220 volts or for any other pressure, depending upon the pressure of the supply mains. Ordinary 8 volt pocket lamps may be employed, and operated by primary cells if power circuits are not available.

The lamps marked 1, 3, 5 and 7 are the uncolored lamps and those marked 2, 4, 6 and 8 are the green colored lamps. These lamps are wired up as shown in the drawing to a series of small brass strips, numbered to correspond with the various lamp terminal connections. A perforated cardboard disc, D, arranged to turn about its center by a knob, H, allows certain of the brass strips to make contact with a brass strip, B, held securely in position back of the disc.

From the strip, B, one of the line wires connects with a key or switch, K. The right hand terminals of lamps marked 1 and 2 are connected with another key or some form of circuit interrupting device marked "flicker device" in the drawing.

Suppose the disc, D, is so turned that the letter, B, on it is in a vertical position, then strips 1, 4, 6 and 8 make contact, through the holes in the disc, with the brass back strip, B, and lights 1, 4, 6 and 8 will be lighted when key K is closed.

If all signals are read from the top downward, and if a white light denotes a dash, while a green light denotes a dot, it is evident that the letter B is signaled as dash, dot, dot, dot; or — . . .; or white, green, green green.

Suppose that the disc is so turned that the letter, H, is vertical or opposite the back brass strip, then the springs 2, 4, 6 and 8 make contact through the proper holes, and all four green lamps are lighted when the key, K, is closed; denoting four dots.

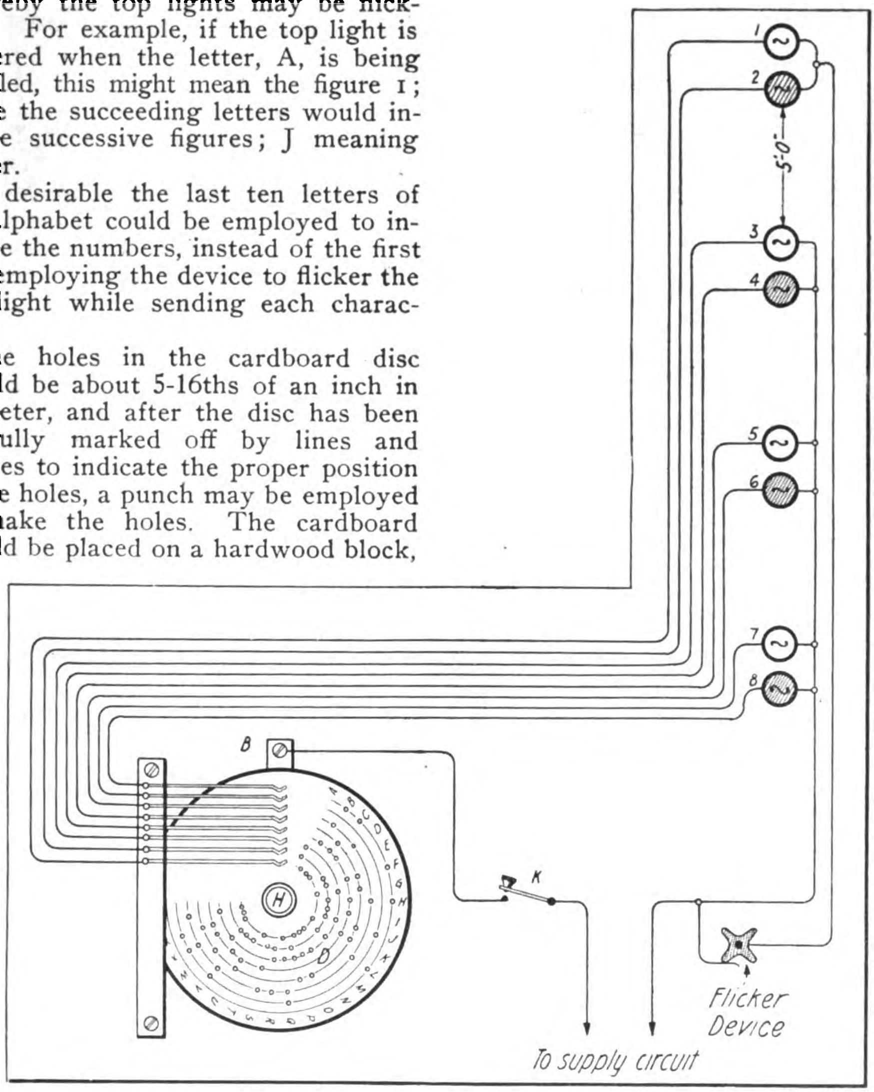
The cardboard disc should be about 8½ inches in diameter, and should be very carefully marked off into sectors, and these intersected by eight concentric circles. The innermost circle should be about 3¾ inches in diameter. There should be twenty-six radial lines dividing the circle into twenty-six equal sectors if the alphabet is to be employed.

These are really all the characters needed because of the arrangement

whereby the top lights may be flickered. For example, if the top light is flickered when the letter, A, is being signaled, this might mean the figure 1; while the succeeding letters would indicate successive figures; J meaning cipher.

If desirable the last ten letters of the alphabet could be employed to indicate the numbers, instead of the first ten, employing the device to flicker the top light while sending each character.

The holes in the cardboard disc should be about 5-16ths of an inch in diameter, and after the disc has been carefully marked off by lines and crosses to indicate the proper position of the holes, a punch may be employed to make the holes. The cardboard should be placed on a hardwood block,



and the punch given a quick blow with a hammer in order to produce holes without rough edges. Square holes give better satisfaction than round ones, and if a square punch is not available, the round holes can be squared by use of a small sharp penknife.

The distance between each white and each green lamp should be five feet; the farther apart they are the greater the distance the signals are distinguishable. It should be noted that the top light, either a white or a green, is always employed in each signal; also that lamps 1 and 2 are never lighted at the same time; which may also be said of 3 and 4, 5 and 6, 7 and 8.

Each letter is instantly flashed at one operation of the key after the disc has been properly set, thereby considerably facilitating the reception of messages. The ordinary dot and dash code may be flashed by setting the disc for T and using the key as in ordinary telegraphy to flash the top light. Any desired code may be adopted and a disc properly stamped to send it. When one disc has been carefully made, it

(*Concluded on page* 176)

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A Compact Receiving Tuner of Neat Appearance

Of the various types of receiving tuners I have witnessed I believe the one described in this article takes up the least space, for a given wave-length, of any of them. It not only has good working qualities, but it also possesses a very neat appearance. It is to be especially observed that the coupling between the primary and secondary winding is altered by turning the coils at right angles, but unlike the familiar variometer the coils do not telescope; still, the coupling will be found sufficient for the most rigid requirements. In fact, a tuner of this type has been found very efficient in connection with the vacuum valve detector.

The primary and secondary discs shown in Figure 1 are identical in construction, with the exception of the two holes x and y in *B*. These are drilled in the primary disc only and are used for its support. They may be made of either black fibre, hard rubber, or micarta. Wood should be avoided if possible.

The primary is wound with 100 turns of No. 28 S. S. C. wire, with taps brought out every ten turns; the secondary is wound with 200 turns of No. 32 S. S. C.

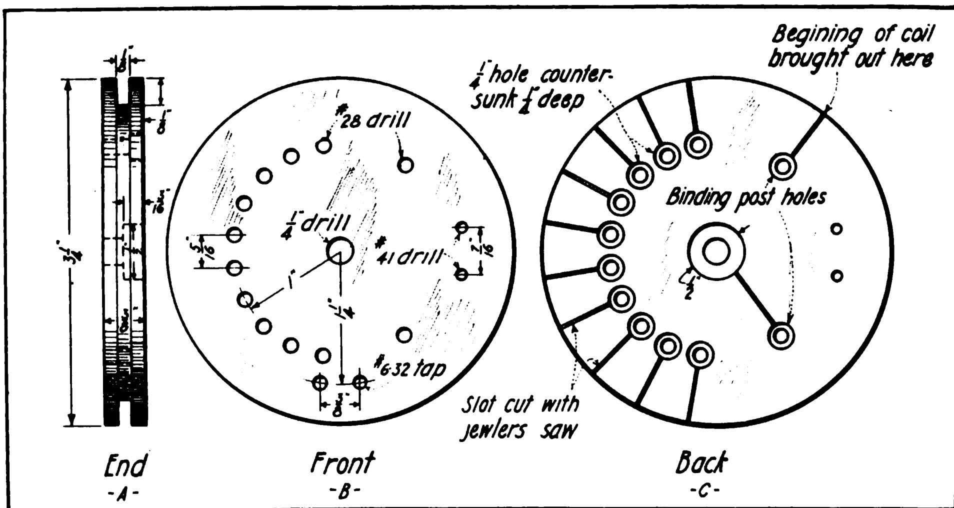


Figure 1, First Prize Article.

with taps brought out every twenty turns. When the desired number of turns, for a tap, is reached, the wire is looped, twisted, and pulled through the slots shown in *C* (Figure 1). The winding should not be placed until the final machining of the discs is completed.

The dimensions of the hinge for mounting the discs are shown in Figure 2. If this size can not be obtained, of course the holes for the hinge in Figure 1 will have to be changed accordingly. The bushings shown in Figure 2 are made slightly larger in diameter than ¼

of an inch, and are forced in the holes. Two of each size of washer in Figure 2 must be made. For the switch blade

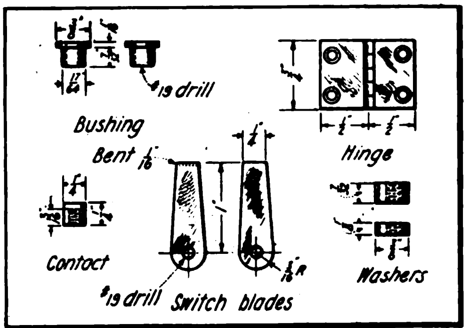


Figure 2, First Prize Article

No. 28 gauge sheet brass is very suitable. The contacts being of standard size, may be procured at any supply house. Fairly heavy escutcheon pins, with the heads cut off, should be placed at the first and last contact, to act as stop pins for the switch blades shown in Figure 4.

Figure 4 shows the method of assembling the switch, etc., and the discs mounted on the base. To bring leads out from the center of the switches, the wire may be soldered to the edge of the

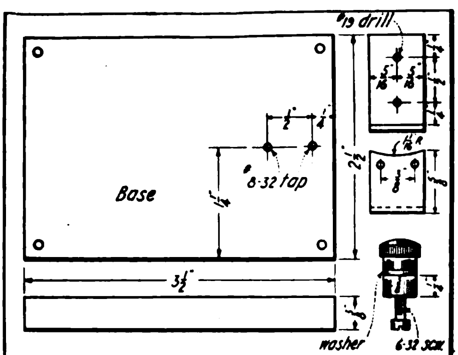


Figure 3, First Prize Article

washer under the head of the screw, then to the binding post.

The other connection comes from the beginning of the winding. All connections should be soldered.

Two pieces of book-binders cloth should be cut and glued to the inside of both discs. As this covers up the taps and screw heads, it will greatly improve the appearance of the instrument. Further improvement may be effected by stamping, by means of steel dies, the corresponding numbers opposite each contact, and filling in with white ink. As a last suggestion I may say that if the entire instrument is finished in nickel plate, the amateur will possess a piece of apparatus to be proud of.

Norman F. Schmidt, *Pennsylvania.*

SECOND PRIZE, FIVE DOLLARS

A Design for a Combination Vacuum Valve Receiving Set

I have designed a universal cabinet receiving set, the circuits of which take full advantage of the various receiving systems developed for amplification by means of the vacuum valve. This receiver can be used for short wave regenerative reception, or the bulb may be employed as a single set amplifier to a crystal de-

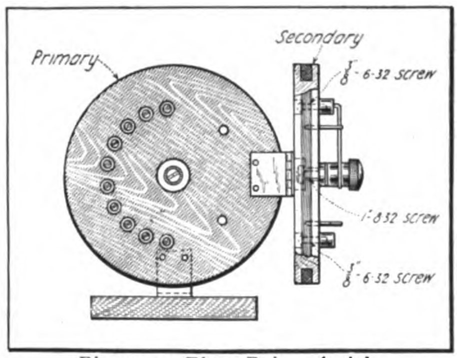


Figure 4, First Prize Article

tector. Furthermore, in order to make the change from one circuit to the other, it is only necessary to change the position of a few switches.

The general idea of assembly is shown in Figure 1, the two coils on either side of the panel being the loading coils for the secondary circuit. The position of the tubular vacuum valve bulb is clearly shown and the necessary switches for changing from one circuit to another.

The base of the instrument upon which the cabinet is placed measures 40 inches by 8 inches, the cabinet dimensions being 24 inches by 20 inches by 8 inches. Upon the projections of the base the secondary loading coils are placed in a vertical position and, if desired for purposes of appearance a top, 40 inches by 8 inches, may be placed over the cabinet.

It is to be especially noted that this cabinet does not contain any tuning apparatus other than the secondary loading coils, because the writer was well aware that the majority of amateurs prefer to employ their own make of tuner. I sug-

gest that if the amateur proposes to incorporate an inductively coupled receiv-

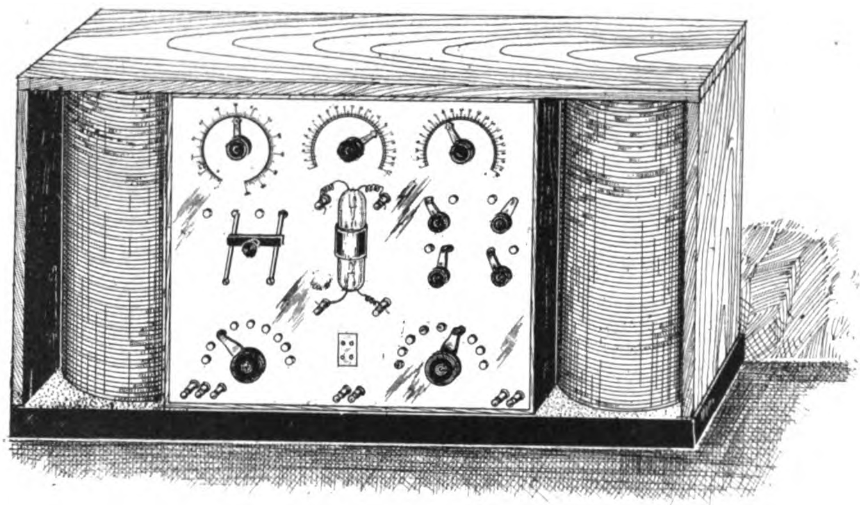


Figure 1, *Second Prize Article*

ing tuner within the cabinet, that a multipoint variometer be employed, because it requires but little space. The regenerative features of the set may be placed on the top of the cabinet if desired.

A complete diagram of connections is shown in Figure 2 the arrangement of circuits being in accordance with the best known practice. For instance, the majority of receiving sets now on sale have three binding posts leading to the valve elements; one leading to the grid through a small fixed condenser: one leading to the plate, and a third leading through the B battery to the filament circuit. These three binding posts are connected to posts 2, 3, and 1 respectively.

The operation of the apparatus shown in my design, is as follows:

When both the D. P. D. T. switch, D, (which is preferably of the sliding type) and the two point switch, H, are thrown to the left, the instrument is connected for regenerative working; but when both switches are thrown to the right, the instrument is connected to receive from the coupler which is connected to posts 4 and 5. If a triple pole double throw switch can be procured, the function of switches D and H may be combined. When receiving from the coupler, if switch A is thrown to the right, the instrument is connected to receive damped oscillations, but if the switch is thrown to the left, the instrument is connected to receive undamped waves. If it is desired to receive undamped waves, use is made of the loading coils, L-1 and L-2, both of which are 20 inches in length and 6 inches in diameter, wound with No. 32, S. S. C. wire, ten or more taps being taken from each.

If the instrument is to be employed as a one-step amplifier to increase the signals of another detector, such as a carborundum crystal, switch A and switch H are thrown to the right, and switch X is then closed which connects in the choking coil. When the instrument is used in conjunction with the regenerative set, the phones are connected to the regenerative terminals, but when the instrument is used otherwise, the phones are connected to posts 6 and 7.

Any three-element vacuum valve may be used. C-1 is the usual small blocking condenser. C-2 is a small variable condenser of .0025 M.F. which permits the use of short loading coils. The choke coil, or auto transformer, consists of four pounds of No. 32, S. S. C wire wound on an iron wire core 14 inches by 2 inches. The secondary of a 1-inch coil with an iron core will suffice. S is a double push switch of the miniature type which controls the A and B batteries in the cabinet.

A potentiometer and rheostat are used to vary the current. V is a coil of wire consisting of fifty-two turns of No. 32 S. S. C. wound in the same direction as the grid. It is connected in series with the A battery and may be short-circuited by switch V. This coil slipped over the

bulb, sets up a magnetic field which makes the valve especially sensitive to short wave-lengths preventing in part the fading away of signals.

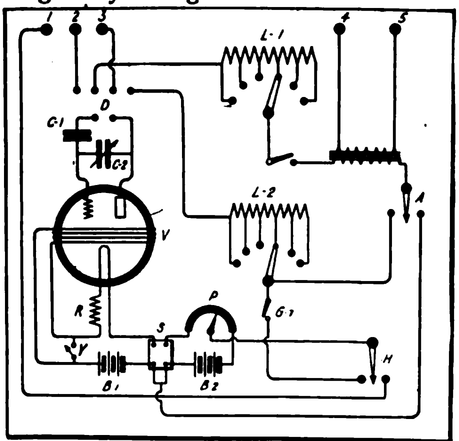


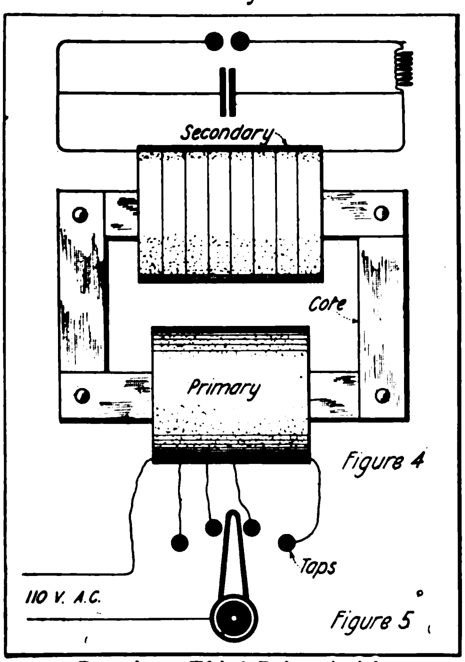
Figure 2, Second Prize Article

This instrument is not bulky and presents a very nice appearance, making a neat addition to any station. It will give excellent service irrespective of the circuit in use.

JOSEPH MORRIS, JR., *Louisiana.*

THIRD PRIZE, THREE DOLLARS
How to Make a ¼ K. W. Step-Up Transformer

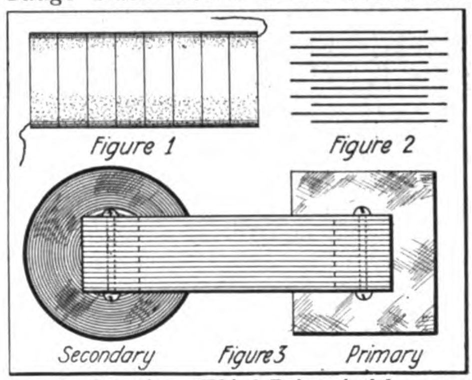
Many an experimenter has wanted a ¼ K. W. transformer, but being unable to secure the secondary coils he is forced



Drawings, Third Prize Article

to give up the idea. I will therefore endeavor to show your readers how the parts of a well-known device can be used for this purpose to advantage.

First, secure two old style Heinz coil units such as used in earlier model Ford cars and carefully take them apart, taking care not to injure the secondaries, which should appear as shown in Figure 1. Next, get about 3 pounds of No. 28 Gauge black iron and cut about two-



Drawings, Third Prize Article

thirds of it into strips 11 inches by ⅞ of an inch, and the remaining third into strips 4½ inches by ⅞ of an inch. Next, shellac each strip and allow it to dry.

Go to an electric store and purchase two pounds of No. 16 D. C. C. magnet wire. Assemble the primary core as in Figure 2, taking particular care to overlap the sheets. Then bind them tightly with tape or empire cloth if available. After this is completed, wind on the first layer of the primary coil and when it is completed, bind it with tape and start the second layer. When the third layer is on take a tap off of each layer. A coating of tape should be placed between each layer.

Next assemble the secondary core, following the method shown in Figure 2, but do not bind with tape. Slide on the secondaries and complete the core with smaller pieces of iron. Then assemble the transformer, as in Figures 3 and 4. This will make a very serviceable little transformer for all-around work.

Figure 5 shows the complete connections.

The transformer should now be connected to 110-volt circuit with a suitable condenser across secondary. If at first a fat spark is not produced reverse the connections between the secondary units.

W. WAYNE ALTER, *Pennsylvania.*

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headquarters, 42 Broad St., New York

H. H. of Bottineau, North Dakota, tells us that during the time amateurs were allowed to work their apparatus, he had at his command stations within a radius of several thousand miles, the naval stations being heard with great clearness and "NAT 50 feet from the phones." FL was heard sending press to "somewhere" in the United States on about 6,000 meters. POZ was easy from four o'clock in the afternoon on into the evening.

Regarding transmission by spark coil, he remarks:

"I never attempted long distance transmitting as I only possessed a one-inch coil, but with this, sixty-two miles could easily be covered night or day, and forty-one miles using one old dry coil half spent.

"During the closing of our stations we will have to be content with repairing apparatus and studying up on matters which have been a little dim to us heretofore. And last, but not least, we should help our country in this time of need by offering our services to the Government as wireless operators whenever we may be required."

I have read with much interest, the June, July and August issues of THE WIRELESS AGE. No doubt, some of the amateurs would be glad to learn of a freak occurrence which I encountered last winter. The details of the incident follow:

Station 9 AFW of North Manchester, Ind., was operating a 1 Bull Dog coil. I had been acquainted by mail with the operator for a little over a year, but naturally, had never heard his signals.

One fine, cold, snappy night last December 9 AFW was calling an amateur a few miles away. The signals came in clear and steady, but not very loud. The wave seemed to be about 500 meters.

I immediately dropped him a card and asked if I might be mistaken in the call. I requested him to call me at eight o'clock a few mornings later.

At the time stated, I tuned to his wave, and in came 9 AFW nearly three times louder than before. He claimed to be using a one-inch Bull Dog coil on ten used dry cells—no helix, no condenser, but merely the gap hooked across the coil. I could hardly believe it, as I copied his signals through two commercial stations on 600 meters.

Later, I received a card from him stating his aerial was about 200 feet in length and 75 feet in height.

The receiving set used at my station was an audiotron set of my own construction. The distance between 9 AFW and 9 SL (myself) is a little over sixty miles.

(*Concluded on page 174*)

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

F. G., Brooklyn, N. Y.:

You evidently have been misinformed concerning the adjustment of a transmitting set. If the open and closed oscillation circuits of a radio transmitter are independently adjusted to the wave-length of 600 meters, the radiated wave will be of this length only under the following conditions: If the closed oscillation circuit contains a spark gap which gives proper quenching, then the length of the radiated wave will be that of the adjustment of the antenna circuit. If, however, the spark gap does not quench properly, there will be an interchange of energy between the opened and closed oscillation circuits. This reaction will cause two frequencies of oscillation and the antenna will radiate two waves.

Coming back to the first part of your query with regard to the adjustment of a receiving set, it is quite possible to vary the wave-length of a secondary circuit by inductance alone as well as in one provided with a variable condenser. The necessary capacity in such circuits is found in the self-capacity of the coil and also the additional capacity which exists in the carborundum detector itself. You, of course, understand that the open and closed oscillation circuits of a radio receiving set must be tuned exactly to the same wave-length for the maximum response.

Regarding your last query: Nagaoka's formula for the calculation of inductance appears in the textbook, "Practical Wireless Telegraphy," copies of which can be purchased from the Wireless Press, Inc., 42 Broad Street, New York City.

* * *

H. E. H., Bottineau, North Dakota:

We cannot interpret the call letters you mention in your first query. The majority of them are foreign stations, the locations of which we do not know.

In regard to the calibration of a variable condenser: We are under the impression that you can have this done at the United States Bureau of Standards at a slight cost. We also believe that such concerns as the Manhattan Electrical Supply Company of New York City can arrange with some laboratory to carry out this calibration.

The resistance of a wire to radio frequencies can be determined by the following formula:

$$R = Rcr\sqrt{0.0058\ N}$$

Where N = the frequency of the current, Rc = the direct current resistance of the wire,

r = the radius of the wire in centimeters.

Answer to fourth query: Yon can obtain an ammeter range, forty to 240 milliamperes, from the Roller Smith Company of New York City; any of the advertisers in this magazine selling electrical instruments will be able to supply you with such an instrument.

We have no information relative to the power of the Naval station to which you refer.

* * *

G. W. F., Seattle, Wash.:

If you had observed your Marconi 2 K.W. 500-cycle transmitting set more closely, you would have seen that the quenched gap is cooled by air-circulating blades which are attached to the disc of the rotary gap, an air duct leading from the rotary drum to the quenched gap. It is important that the quenched gap be properly cooled by external means, such as an air blast.

Answer to second query: Experiments indicate that the average commercial aerial possesses a minimum resistance when it is worked at a wave-length about twice its natural wave-length, but this is not often done in practice. In regard to the problem which you have presented: While it would undoubtedly require more inductance to raise the wave-length of the 130-meter antenna to 200 meters than the one having a natural wave-length of 190 meters, it is probable that you will obtain a greater current with the larger antenna; on the other hand, the shorter aerial will radiate the sharpest wave because of the amount of inductance which must be inserted at the base.

Answer to third query: The actual capacity of the condenser in the closed oscillation circuit of a radio transmitter is governed by the wave-length to be employed, the power, frequency and the voltage of the transformer. A compromise must generally be effected between all of these quantities.

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By MAJOR J. ANDREW WHITE

Chief Signal Officer of the Junior American Guard

IN PRESS

This manual, the first of its kind, has been prepared for those who will respond to the call to the colors. It contains all the essential information on the broad subject of army signaling, including instruction, field work and tactical employment of visual and electrical signaling methods. Compiled to enable amateur wireless men to qualify for Signal Corps service, in which they may serve most efficiently. It supplies the basis of organization and training for those who will later be eligible for service with expeditionary forces or home defence bodies.

Prepared with the full co-operation and approval of the Chief Signal Officer, U. S. Army.

PRICE NOT FIXED

It is not advisable to employ a large amount of inductance in the closed oscillation circuit as it will occasion unnecessary energy losses; generally a maximum value of 30,000 centimeters is employed. It is quite possible to transfer energy from the closed circuit to the open circuit with inductance of 3,000 centimeters at the primary winding.

We cannot answer your fourth query specifically because we do not know what type of vacuum valve receiving circuit you propose to use. If a regenerative circuit is employed and the apparatus is to be used at the wave-length of 200 meters as you say, the inductance of the regenerative coupler will be sufficient to tune the telephone circuit to the wave-length of 200 meters.

We cannot answer your last query specifically because we do not know the voltage of your high voltage transformer. We can, however, state precisely that the capacity of the condenser, in order that the set may be operated at the wave-length of 200 meters, should not exceed .01 microfarad and is preferably of a value of .008 microfarad.

* * *

C. W. G., Indianapolis, Ind.:

If you intend to transmit at the wave-length of 200 meters, we are inclined to believe that the antenna, 60 feet in length by 50 feet in height, consisting of four wires, will give the best results.

Whether or not it would be advisable for you to rewind the secondary winding of your high voltage transformer in order to obtain 20,000 volts is a question that can best be answered by the manufacturer. The amateur's transformer should have secondary voltage of from 15,000 to 18,000 volts, but if one goes above 20,000 volts in the design of the secondary, the radio apparatus will require extremely careful insulation and in addition such voltages may call for an abnormally long spark gap in the closed circuit which will occasion energy losses. A transformer with a secondary voltage of 8,400 is too low for a 200-meter working because it requires a condenser of such excessive capacity as to exceed the wave-length of 200 meters.

* * *

J. W. H., Wooster, Ohio:

It is impossible for us to calculate the number of turns required on the primary winding of your transformer unless we know the voltage and the frequency of the current upon which it is to be operated.

The insertion of an iron core in a coil of wire increases the energy losses due to the production of hysteresis in the iron and the production of eddy currents.

Offhand, it would seem that your secondary composed of 15,000 turns of No. 34 wire would do for a 1 K.W. transformer. The secondary voltage is apt to be rather high with a properly designed primary, somewhere in the neighborhood of 20,000 volts.

Regarding the construction of a simple galvanometer: If the voltage of the current employed is low, your galvanometer can be wound with No. 20 or 22 S.S.C. wire, but if the voltage is rather high you should use a much finer wire. The actual size of the wire depends entirely upon the purpose to which the galvanometer is to be put.

It is quite possible, as you mention in your last query, to rewind the 80-ohm bobbin which is now filled with No. 36 wire, with No. 38 or No. 40, and with certain types of crystal detectors you may obtain better results by following this plan.

* * *

H. H. R., Chicago, Ill., inquires:

Ques.—(1) Is it considered a violation of the President's executive order to construct radio apparatus?

Ans.—(1) Our understanding is that it is a distinct violation during the war.

Ques.—(2) Just what pieces of apparatus come within the scope of this regulation?

Ans.—(2) This is a matter upon which we have received no definite information, but we are under the impression that any part of the equipment which goes to make up a complete wireless telegraph set would come under the ban.

Ques.—(3) Are we to understand that amateurs are not permitted to construct, for instance, a high voltage transformer during this period?

Ans.—(3) If the high voltage transformer is to be used specifically for radio work at some future date there is no doubt that it would come within the scope of the regulations. However, you can satisfy yourself more clearly on this point by communicating with the radio communication officer in your district.

Ques.—How can an amateur employ his time most profitably during this period?

Ans.—He is now afforded an unusual opportunity to familiarize himself with the theory of wireless telegraphy and he is urged to purchase well-known textbooks upon the subject. He should also endeavor to obtain an elementary knowledge of radio engineering, as his services may in the future prove of value to the Government. Naturally, the more he knows before enlisting, the higher appointment he can obtain. It might be well for those who contemplate enlisting in the Naval Reserve to study navigation. Knowledge of gas engines, automobile driving, airplanes and airplane engines offers a highly interesting field for investigation, and the man who has leisure time on his hands will do well to follow such lines of training.

* * *

A. W., Seattle, Wash., inquires:

Ques.—(1) What substitute can I use for the test buzzer to create the signals of the continental telegraph code for practice?

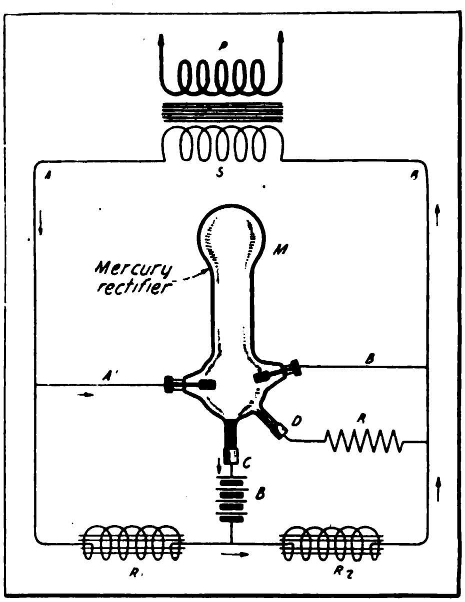
Ans.—(1) Any sort of mechanical circuit interrupter would fulfill your requirements, or you could connect your receiving telephone across the armature of a motor with a 1 microfarad condenser in series. If the motor revolves at a fair speed a very clear tone will be produced, one that will equal the best high pitch buzzers. The "roundness" of the tone will depend largely upon the capacity of this condenser.

C. T. L., St. Louis, Mo., inquires:

Ques.— Please state briefly the theory of the mercury arc rectifier and give a diagram of connections showing how it is used to charge a storage battery.

Ans.—One circuit for the mercury arc rectifier is shown in the accompanying diagram. The general theory follows: First, it consists of an exhausted tube having one or more mercury electrodes to which is applied an alternating current. When current flows towards the negatve electrode or cathode, ionized vapor is produced, but if the direction ot the voltage is reversed so that the negative electrode now becomes the positive electrode, the current will not pass. The current always flows toward the cathode (or negative electrode) which is kept excited by the current itself, but unless some means is supplied to maintain the flow of current continuously toward the negative electrode, the tube would cease to operate after the first half cycle of alternating current took place.

A circuit diagram of the mercury vapor rectifier connected to a storage battery is shown in the drawing wherein it is noted finally that both alternations of a complete cycle of current flow through the battery.



In this diagram the glass bulb contains two graphite anodes, A^1 B^1, and a mercury cathode, C. A small starting electrode, D, is connected to the alternating current circuit through a resistance coil, R. By rocking the tube, an arc is formed which places the rectifier into operation. When the terminal, A, of the secondary winding, S. is positive, the arc within the bulb takes place between A^1 and C through the battery, B-1, through the reactance coil, R-2, and back to the negative side of the line, B.

When the impressed alternating current voltage falls below a value sufficient to maintain the mercury arc against the reverse voltage of the arc and the battery, B-1, the reactance coil, R-2, which has formerly been in the charging circuit now discharges, setting up a reactive current which flows in the same direction as the original current. This maintains the arc in the rectifier tube until the voltage of the alternating current has passed to zero, reversed and built up to such a value as to cause the anode, A^1, to have a sufficient potential to start an arc between it and C. The coil, R-1, now discharges, thus maintaining the arc from B′ to C until the voltage at the anode B′ has become sufficient to permit the passing of an arc from it to the anode. Current from the transformer now flows from B, through B′, through C, through R-1 back to A. Various modifications of this circuit are employed.

THE N. A. W. A. BULLETIN

(*Concluded from page* 168)

I have read of so many spark coil records that I think I will pass mine around for inspection.

Prior to the war, I was an amateur, residing in Iowa Falls, Ia. When war was declared, I procured a first grade commercial license and joined the Marconi operators.

But to get back to my story. One night in the latter part of March, I heard 9 ZI who was located at Eldora, twenty-two miles away, calling CQ. I was using a one-half inch spark coil of William B. Duck's manufacture, an eight-plate condenser, and small oscillation transformer. I answered him and, to my great surprise, he came right back. We conversed for half an hour. After that, I succeeded in getting him several times.

This can be verified by writing 9 ZI.

I don't claim any receiving records, although before I joined the vacuum valve users I could hear WUJ and other extreme southern stations, with phones on the table, using a crystal detector and one wire aerial.

It would be a great pleasure to hear some of my old amateur friends again, and I hope the time will soon be here when we can hear their gentle voices again. William H. Earle (9 AMH), *Texas.*

A. R. L., North Dakota:

The electrical efficiency of a dynamo is obtained by dividing the energy delivered by the sum of the power lost in the armature and in the field coils. Then if

W= the useful or available power;

W_a=the I^2 R losses in the armature;

W_f=the I^2 R losses in the field poles;

then the electrical efficiency is obtained as follows:

$$\text{Electrical efficiency} = \frac{W}{W + W_n + W_f}$$

The commercial efficiency of a dynamo is obtained by dividing the energy delivered by the dynamo by the sum of the mechanical, electrical and magnetic losses. In other words

$$\text{Commercial efficiency} = \frac{\text{output}}{\text{intake}}$$

It will be found that the commercial efficiency of a dynamo varies with the load imposed upon it, and this factor is always less than the electrical efficiency.

In the case of a motor-generator, you can observe its commercial efficiency by placing a wattmeter in the motor and in the generator circuits; by noting simultaneously the reading of the two meters under given conditions of load. the commercial efficiency of the machine will be obtained at once. The normal efficiency of the machines of the types you mention is approximately sixty-five per cent.

The electrical losses in any dynamo include the I^2 R losses in the armature field, the losses due to eddy current and hysteresis. In addition we have the mechanical loss of friction between the armature shaft and its journal bearing; also the friction of the brushes upon the commutator.

The break-down voltage of grey pressboard having a thickness of 0.35 of an inch is 8,500 volts.

* * *

G. R. B., Pittsburgh, Pa.:

You can determine the size of wire in circular mils to transmit any given horsepower any distance by the following formula, provided the voltage and the efficiency of the motor are known.

The formula is expressed as follows:

$$\text{C. M.} = \frac{\text{H. P.} \times 746 \times L \times 10.79}{E \times e \times \%M}$$

where E=the voltage required of the motor;

L=the length of the circuit in feet;

e=the voltage drop on the line;

H.P.=the horsepower of the motor;

%M=the efficiency of the motor expressed as a decimal. If you will follow out this formula you will have no difficulty in making the calculations you require.

* * *

K. R. A., Boston, Mass.:

A complete description of the Arlington station and other activities of the United States Naval Radio Telegraphic Service appear in Volume 4, No. 5 of the Proceedings of the Institute of Radio Engineers for October, 1916.

* * *

M. R. B., Springfield, Mass.:

The phenomena of electric radiation of wireless telegraph aerials are explained in simple language in detail in "Wireless Telegraphy and Telephony," by A. E. Kennelly. Copies of this publication can be obtained from the Wireless Press, Inc., 42 Broad Street, New York City.

* * *

M. R. A., Cincinnati, Ohio:

Professor Morse made his first experiments with the earth current telegraph system alongside a canal near Washington in the autumn of 1842. He laid parallel wires on either side of the canal, grounded at both ends through copper strips. On the receiving side he connected a galvanometer in series, and on the transmitting side a battery with a telegraph key. The system he employed was not "wireless" in the sense of modern day systems, because he positively did not utilize electro-magnetic waves. The current flowing in the receiver was due to the simple phenomenon of divided circuits, that is to say, a portion of the return earth current of the transmitter flowed through the copper plate and galvanometer which were located on the opposite side of the canal. The wires on either side of the canal were grounded on each end through copper plates which were immersed in the water.

* * *

T. B. L., Chattanooga, Tenn.:

You will find a complete description of the two-wheel army tractor which was driven by reins, in the May, 1917, issue of the Scientific American. It is a gasoline operated tractor, but is controlled by reins. as a horse.

* * *

A NIGHT SIGNALING SYSTEM

(Concluded from page 163)

may be used as a pattern for quickly making any number of similar discs.

For signaling between the shores of lakes, between boats or between any land stations, this system is of considerable value, and will give the amateur excellent practice in receiving messages.

EDITORIAL NOTE: We advise experimenters living in the vicinity of the Atlantic and Pacific coasts not to carry on their original experiments with this device without first obtaining Government permission, as such signaling might be misconstrued and result in a spy scare. Signaling by lights is quite as interesting as signaling by radio and the suggestions given by the author may aid future members of the Naval Reserve to grasp the fundamentals of visual signaling.

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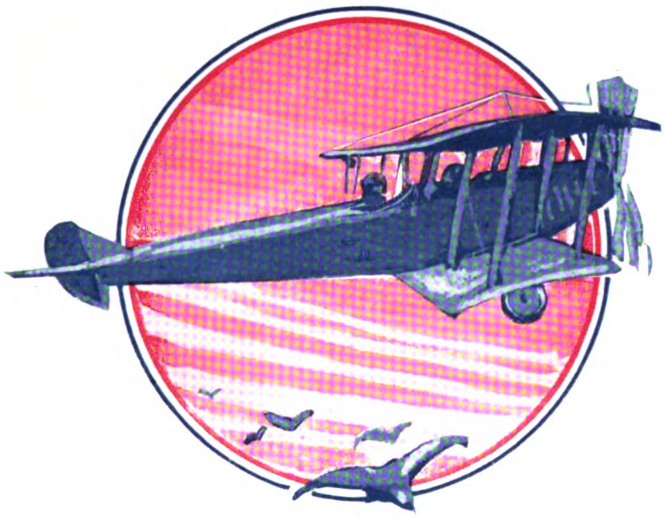

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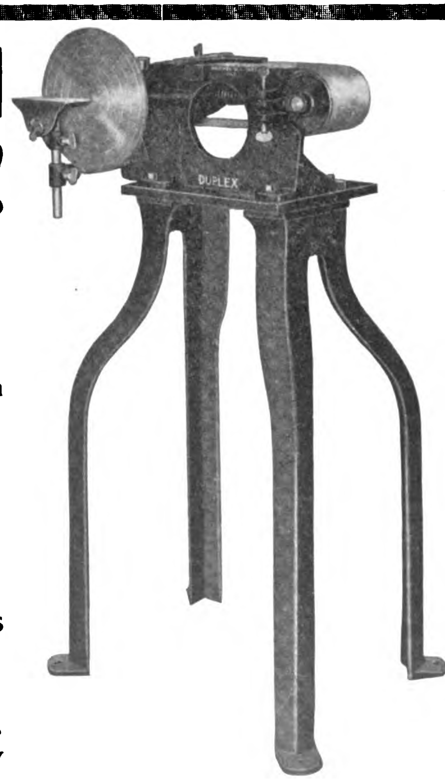

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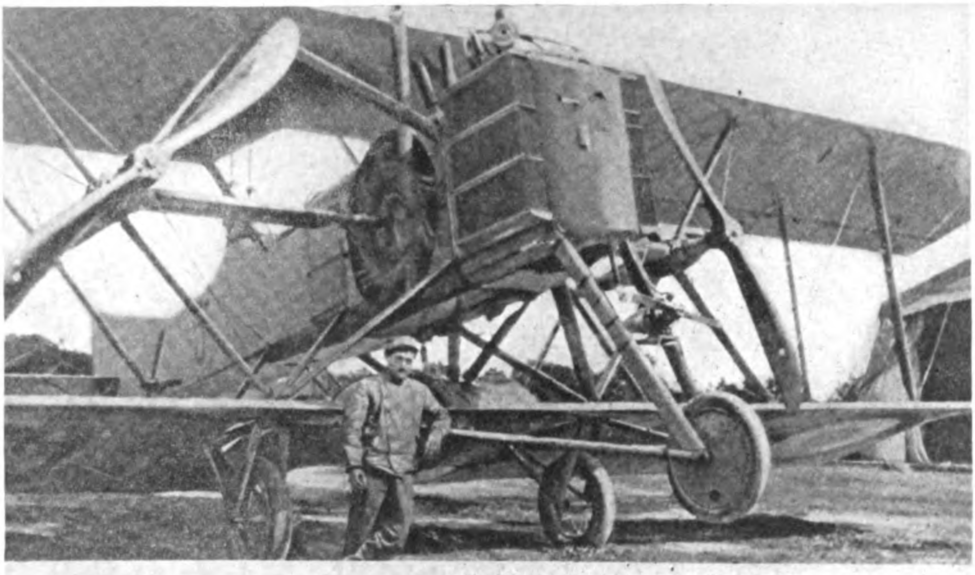
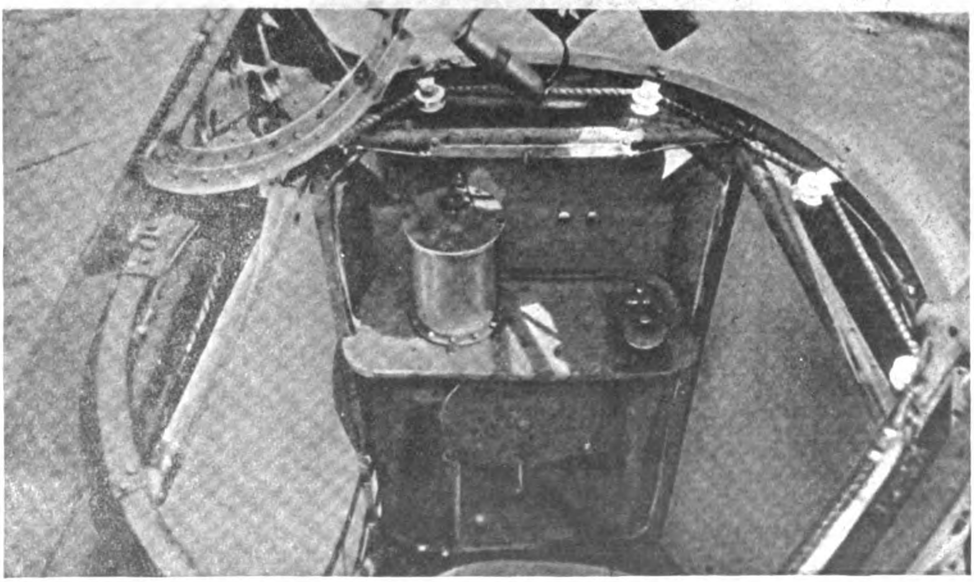




In the upper view of a war biplane may be seen, just below the large propeller to the right, the small air screw which is actuated by the motion of the air and drives the small dynamo, which supplies power to the wireless set. Below is shown the interior of the cockpit with wireless set in place. It is now a well known fact that all artillery fire spotting is done by wireless communication from aeroplanes

VOLUME 5, No. 3 DECEMBER, 1917

THE WIRELESS AGE

WORLD WIDE WIRELESS

Marconi on the Advantages of Closer Co-Operation by the United States with Her Allies

GUGLIELMO MARCONI, who recently returned to Rome from a tour of the front from the mouth of the Piave to Monte Grappa, in the course of which he inspected the wireless apparatus on the battle lines, has commented pointedly on the advantageous effect of a closer co-operation by the United States with the Allies.

"What we desire ardently," he declared, "is the closest co-operation and union with America. I have been able already to appreciate the co-operation of the United States in this great war, but it would bring it home to the Italians more effectively if they knew that America also was at war with our nearest enemy, Austria."

As a representative Italian, Mr. Marconi speaks with authority. His statement was made before the United States had declared war on Austria.

Mr. Marconi also spoke encouragingly of conditions in the Italian army.

"The reorganization of the entire Italian army is proceeding apace," he said. "It makes us confident that the onward march of the enemy will be definitely stopped.

"I saw the Duke of Aosta (Commander of the Third Army), General Diaz (commander-in-chief), General Badoglio (second in command) and other leading commanders. All were filled with hope that the worst is over, that the revival of the morale of the soldiers, which is constantly more noticeable, may give unexpected results. I found everywhere that the spirit of the troops was very high. The men are desirous of taking revenge for the reverses suffered, and are furious at the thought that any Italians had been cheated into believing Austrian and German lies when the enemy announced the intention to lay down arms if the Italians did the same.

"The navy, operating with the army along the coast and in the lower section of the Piave, is gaining splendid successes, to which the British monitors are contributing. The Italian artillery is doing marvels, getting the last ounce possible out of all the guns along the Piave."

It has been announced that General Diaz, the new commander-in-chief of the Italian armies, will have the assistance of Mr. Marconi in driving back the Austro-Germans. Mr. Marconi has already assumed his duties as a member of the staff of General Diaz.

Speculation Concerning the Electrically-Controlled Boat

THERE is some diversity of opinion concerning the operation of the German boats officially described by the British as "electrically controlled." One of these craft made an attack on November 3 on British vessels patrolling the Belgian coast. The attack was unsuccessful and the boat was destroyed.

An official announcement later made in London said that four other electrically-controlled German boats had been destroyed. The naval authorities, it was said, had known of the boats for some time and regarded them as freaks. The first of these craft, according to this source of information, was wrecked a considerable time ago when it came into collision with a pier on the German coast.

In Washington this announcement of the use of a new machine of destruction by the Germans was interpreted to mean that the enemy had made an application of the device for which basic patents were obtained by Rear Admiral Fisk about twenty years ago. John Hays Hammond, Jr., made a practical application of the theory to boats and torpedoes, Congress appropriating nearly a million dollars to purchase his patents. A board, composed of Army and Navy officers, was formed to judge of the value of the device.

By means of the Hammond device a swift motor boat could be directed from the shore by means of the manipulation of a radio telegraph key in any direction in which the operator chose to send the craft. A similar control device, it has been pointed out, might have been employed by the Germans to propel their boats.

From Berlin came a dispatch to the effect that the boat was the invention of Christoph Wirth, a teacher at Nuremberg, Bavaria. Wirth's invention was told of in the Mariner-Rundshau approximately six years ago. By means of this device a crewless craft was directed from land about the waters of a lake, wireless being employed. The operator fired shots from the guns on the boat, hoisted flags and set bells a-ringing.

These theories all point to the fact that the boats which have come into notice recently, were wireless craft. On the other hand, a London report concerning the vessels says that they are operated from shore by wire which they pay out as they make their way through the water, an aeroplane in its wake signaling back to the gunners on land.

What has been told regarding the craft is too meagre to give basis for anything but speculation as to the methods employed in operating them. Reports to date, however, indicate that, as employed by the Germans, they are not as formidable as their U-boats.

The Wireless Enemy in Our Own Country

OFFICERS of the Government continue to show by their activities that they are alive to the dangers from enemy wireless and wireless men in this country.

The president of a wireless concern in Elmira, N. Y., was arrested on November 12 because, according to the Department of Justice, he was "potentially able to do great harm to internal military and business interests of this country." He installed a wireless set on the Kaiser's private yacht and at one time was a member of the German emperor's personal retinue as a wireless operator.

In some instances the investigations of the Secret Service agents bring unexpected results. An agent visited a house in Providence, R. I., to investigate a wireless plant. In response to his rapping on the door a sad-faced woman appeared. The agent asked for her son, the operator of the wireless set.

"He is not here," she answered, with tears running down her face.

"Where is he?" asked the Secret Service man.

"Over in France, fighting for his country," was the proud reply.

The owner of the set had installed it for the purpose of practice. Afterwards he was called to the colors.

The activities of the Secret Service agents extend from coast to coast. Wireless apparatus has been confiscated recently in Freeport, Long Island;

Norwich, Conn.; Trenton, N. J., and San Francisco, Cal. In Norwich a wireless set was found secreted among the branches of a tree.

The Seeadler Heard of Again

THE German sea rover Seeadler is heard of from time to time in the South Pacific. A recent report says that the British steamship Matunga may have been captured by members of the crew of the Seeadler and may now be cruising about in search of prey.

The Matunga, bound from Brisbane to Rabaul District, reported to the latter place by wireless on August 5 that she would arrive there two days later. She has not been heard from since.

According to a report from Rabaul, a steamship closely resembling the missing craft, although painted slate color, has been seen on several occasions by different vessels. When the strange ship was asked by wireless to reveal her identity she extinguished her lights and steamed away on a different course.

The Employment of Wireless in the Halifax Disaster

THE advantage of having wireless at hand in times of stress was demonstrated when the disaster at Halifax, N. S., in which thousands of lives were lost, occurred. With the land line wires out of commission and the stricken city cut off from communication with the outside world, wireless still remained as a means of getting word to and from the scene of the catastrophe. It was used effectively, too, when a relief train was started from Boston and the War Department was asked to inform the Mayor of Halifax by radio that aid for the sufferers was on the way.

Sending American Propaganda from the Sayville Station

GEORGE CREEL, Chairman of the Committee on Public Information, announced recently that he is utilizing the Sayville wireless station daily to send broadcast 1,000 words of American war news. This is done in the hope that the information will reach Germany. Of course he does not know that any part of it goes beyond the receiving operator or the officers in charge of the German stations, but it is transmitted notwithstanding.

The Proposed Trans-Atlantic Flight of the War Aeroplanes

IT has been suggested that the thousands of United States aeroplanes which are expected to play an important part in winning the war make the flight across the Atlantic in order to reach the battle front. According to the plan outlined wireless will be employed as a means of piloting the flying machines. It is said that the flight can be accomplished in two "hops," the first to the Azores and the second to the continent.

Assuming that this plan is practical, it will result in the solution of the vexed question of how to get our aeroplanes to the front. It would require considerable time to transport the machines across the Atlantic, either shipped in parts or intact. However, it has been estimated that a flight of 3,000 miles would not take the modern aeroplanes more than forty hours, and, reckoning on this basis, the machines would be able to reach the fighting lines within two days after they were completed.

With the aid of the wireless direction-finder the guiding of the aeroplanes

to a given point on foreign shores would not be a difficult task. The piloting of the flying machines has been somewhat of a problem in the past, but with a wireless station established at the place of destination and the aeroplanes equipped with direction-finders, the flight across the Atlantic should not be filled with insurmountable obstacles.

The Frustration of German Plans in China

THERE is more than passing interest in the brief cable dispatch from Tien-tsin that attempts made by German interests to establish the system of a German wireless telegraph company in China have been defeated. The British Legation at Peking, it is stated, has definitely established the position of the Marconi Wireless Telegraph Company under the agreement signed in 1914. Arrangements had already been made, the cable dispatch said, to ship apparatus of the German company from this country where large stocks were available. There is no reason to believe, however, that the Chinese government was aware of these arrangements.

Germany would have obtained a valuable means of spreading her propaganda throughout China if the plan to install the German wireless telegraph company's system had been carried out before the latter country declared war against her. The transmission of pro-German propaganda and news by wireless from Berlin to the stations in China and the dissemination of this information throughout that country would have been considerably facilitated with a radio system in the hands of the enemy.

The World-Girdling Communication Plan Suggested for the Vatican

IF THE suggestion to establish a wireless station on the dome of St. Peter's in Rome in order to keep in touch with the war situation all over the world is carried out the Vatican will have a news bureau without a peer. The plan was evolved for the purpose of obtaining independent transmission of foreign messages of diplomatic character in code as well as to receive confidential reports from the Vatican's representatives abroad.

There has been no complaint from the Vatican regarding the restrictions of censorship, but the advantages of sending and receiving communications by an independent system were doubtless considered in planning the installation of wireless. Since the European war began, special couriers have been employed to convey confidential messages from the Pope or Cardinal Gasparri, the Papal Secretary of State. Communications of less importance have been sent by mail.

The installation of wireless would permit the Vatican to establish communication direct with Switzerland, Austria, Germany and Sweden. The Vatican has been compelled to depend upon newspaper dispatches for news of the minute, but these have not served its purpose satisfactorily because there is always the well-founded suspicion that the items from Germany have been colored or deleted. The Vatican is also much interested in news from Russia, but the same doubt as to its accuracy is attached to the information sent out from there for publication.

It is pointed out that the Italian Government will not discourage the plan because the establishment of wireless would aid in doing away with the congestion on the existing lines of communication. Wireless seems to have solved another problem growing out of the war.

An Exploit of the Moewe as Seen by the Enemy

WIRELESS is so closely interwoven with the history of the exploits of the German sea raider Moewe that a history of the exploits of the craft is incomplete without frequent reference to the art. This is shown in the published extracts from the diary of Count Schlodien, commander of the Moewe. In telling of the capture of the steamship Appam, which occurred before the United States declared war against Germany, he said:

" . . . fast steamers are usually equipped with wireless telegraphy, and if she (the Appam) should try to make use of it as soon as she suspected our intentions, we might be forced to take serious counter measures . . . However she showed no disposition to stop and I had to fire a shot across her bow . . . The Appam visibly decreased speed and soon stopped. But it was at once reported to me that she was sending wireless signals. This did not help her very much as our own wireless men at once jammed her messages so that it became unintelligible. Nevertheless, ships might have still discovered from the interrupted messages that everything was not in order hereabouts.

"I ordered our guns to be trained on her wireless telegraph room, which was in plain sight abaft the bridge. It was all that was needed. The signals stopped."

The capture of the Appam and her arrival in Hampton Roads with the Moewe have been described in a previous issue of THE WIRELESS AGE. Count Schlodien's recital, as far as it concerns wireless, concludes as follows:

"On account of our arrival in more northerly latitudes we received fuller wireless information from Germany, with a lot of good news. Particularly welcome was the notification contained in one message of the award of the Iron Cross to fifty members of our crew. I did not lose the opportunity of personally announcing the awards to the recipients, who were recommended by me for the honor."

The Dependence of German Aviators on Wireless

HOW much dependence German aviators place on wireless is revealed by the views of one of the chief officers of the French Army aeronautical service. After examining some wrecked Zeppelins and one captured intact after a recent raid on London, he analyzed the causes for the failure of the attack.

The failure of the expedition, in his opinion, was due partly to atmospheric conditions and partly to failure to establish wireless communication. The vessels left for England in a moderate west wind, but it turned to the north and when they arose to escape the British anti-aircraft guns a strong gale was blowing in the upper altitudes.

These air ships depend for their guidance, it seems, on the wireless stations in Germany. This is due to the fact that no means have been found for calculating drift and the compass seems practically useless without that. But the German stations failed the vessels in question at a critical time because, perhaps, they were too hard pressed with demands from other airships which had gone astray.

A Hero of the Key

SECRETARY of the Navy Daniels has commended the conduct of C. L. Ausburne, radio electrician, first class, who lost his life when the United States Army Transport Antilles was sunk on October 17. In a letter to Robert Ausburne, brother of the radio operator, who is employed at the Union Club in New York, Secretary Daniels called attention to the bravery of the wireless man

as brought out in the findings of the court of inquiry. They related that Ausburne went to his station to send out a warning by wireless rather than attempt to save his own life.

When the ship was struck Ausburne and Radio Electrician MacMahon were asleep in adjacent bunks. Ausburne, fully alive to the danger of the situation, told MacMahon to put on his life preserver. As Ausburne was on his way to take his place at the wireless key he shouted to his companion: "Goodbye Mac." This was the last that MacMahon saw of him. Afterward he went to the wireless room, but it was locked. The ship was sinking fast and MacMahon attempted to get Ausburne out of the room but without success.

Ausburne first enlisted in the Navy at New Orleans, February 25, 1908. He re-enlisted on March 1, 1916, after eight years' service.

The death of another wireless man, Stanley T. Anthony, radio electrician, first class, occurred on November 19 when the American destroyer Chauncey was sunk in a collision in the war zone. Details of the exact manner in which Anthony met his death have not been made public.

Linking North and South America by Wireless

THE recently announced plan of the Pan-American Wireless Telegraph and Telephone Company to establish communication by radio between North America and every South American state is a noteworthy development of expansion in the commercial wireless field. The plans of the new company include the use of both wireless telegraphy and telephony. Its president is Edward J. Nally, vice president and general manager of the Marconi Wireless Telegraph Company of America.

Argentina, Brazil, Uruguay, Chile, Peru and Ecuador will be brought into close touch with their northern neighbors by means of the Pan-American system, and early in the new year construction of the initial stations will be begun. Stations are also planned for Central America and Mexico.

The American Marconi Company's interest in the new company amounts to stock control; the new enterprise is entirely financed. Rights have been acquired by the Pan-American Company in the patents of both English and American Marconi companies, as well as the Poulsen-Pedersen system. It is announced that high speed transmission and reception during all the twenty-four hours is assured by new inventions and that selectivity and secrecy will also be thus obtained. The commercial service planned is expected to reach large proportions and users of the system are promised reliability, speed, accuracy and cheapness. It is also hinted that wireless telephony is destined to play a very important part in long distance communication. As the service expands and facilities grow, the Pan-American Company will introduce innovations from time to time, such as night letters and week-end letters at greatly reduced rates, a service which Marconi has found of popular appeal in trans-oceanic communication.

Mr. Nally, who as President will guide the destinies of the new addition to commercial wireless, has long been a prominent figure in telegraph circles. His career began in boyhood with the Western Union; he rose to the directorate and the office of vice president and general manager of the Postal, leaving that company to serve in the same capacity with the American Marconi Company. It was under his direction that the great network of high power stations was built, linking the United States by wireless with its dependencies and other continents with America. Further elements of success for the enterprise appear in the fact that business is begun with valuable concessions and that the U. S. Government, recognizing the need for better communication to further South American trade relations, has set its seal of approval on the new company.

Radio Science

A Valve Which Restricts the Flow of Electrons

GEORGE M. WRIGHT of London, England, has designed a special vacuum valve by which the flow of electrons between the filament and anode can be restricted in accordance with any particular set of requirements. The inventor lays stress on the fact that the apparatus shown in Figure 1 is particularly applicable to the elimination of atmospheric disturbances.

The vacuum valve tube shown in the drawing (Figture 1), consists of a coarse mesh grid, D, mounted on the outside of the bulb and a fine mesh grid, d, inside the bulb, which forms a complete screen across the path between the filament and the anode. A fixed potential is maintained between the grid, d, and the

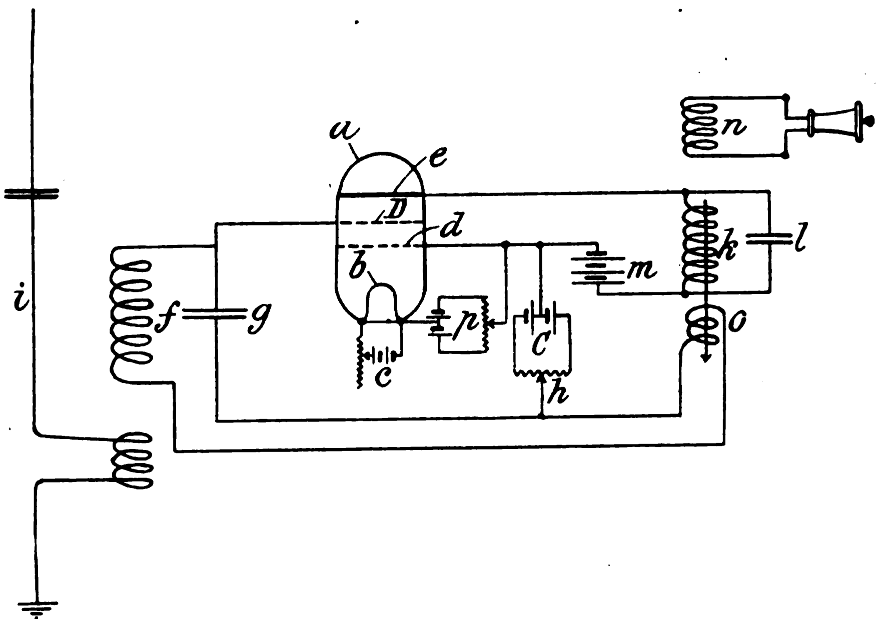


Figure 1

filament by means of a potentiometer, P. The secondary circuit, f, g, and the anode circuit, e, k, l, m, are coupled together at o and k. The outer grid, D, is connected to the inner grid, d, through the resistance, h, across the battery, C.

The important effect of this construction is that the strength of the current or the response in the head telephone in the anode circuit can be limited and, therefore, no matter how great the strength of the incoming signals, the response in the telephone will be limited by the operating characteristic of the circuit. Hence the interference of atmospheric electricity can largely be annulled and the signals from a given transmitting station read with less difficulty.

The Detection of Undamped Oscillations

IT is a well known fact that undamped oscillations cannot be detected by the ordinary radio frequency rectifier because of the continuity of the advancing wave train. Hence some means must be provided at the receiving apparatus

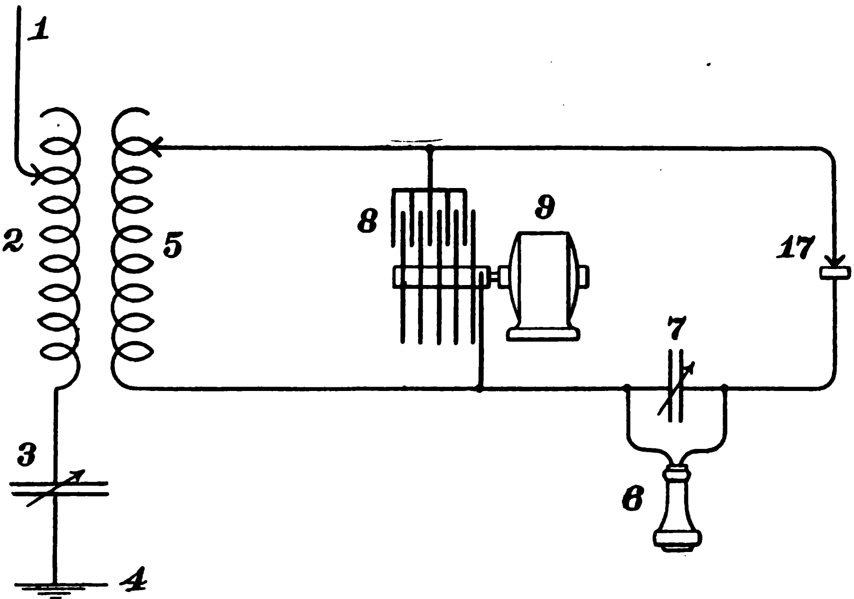


Figure 2

whereby the incoming signals can be converted into an audio-frequency current suitable for operation of the head telephones.

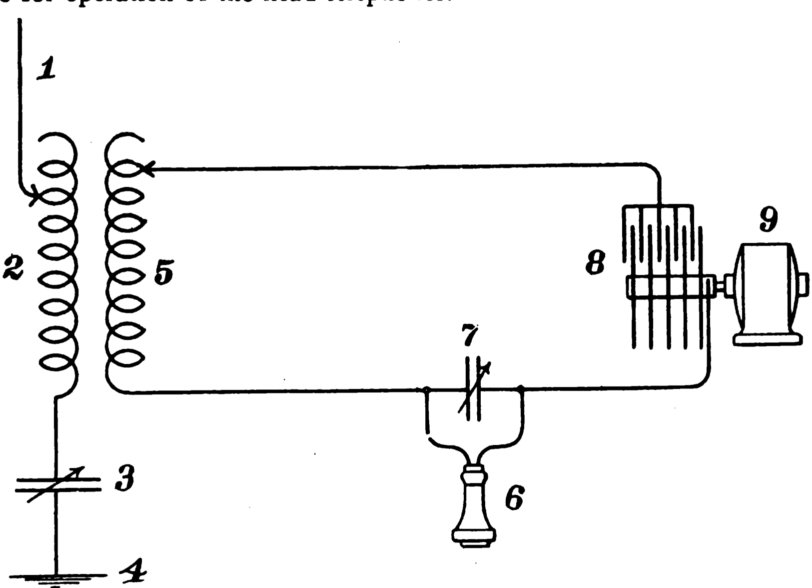


Figure 3

A recent United States patent granted to Elmer E. Bucher, shows a novel method for converting radio frequency currents to currents of audio frequency. The mechanical receivers heretofore adopted for such detection have been either

the tikker or the slipping contact detector, both of which possessed the disadvantage that they were somewhat troublesome in adjustment and would give an impure or imperfect note in the head telephone.

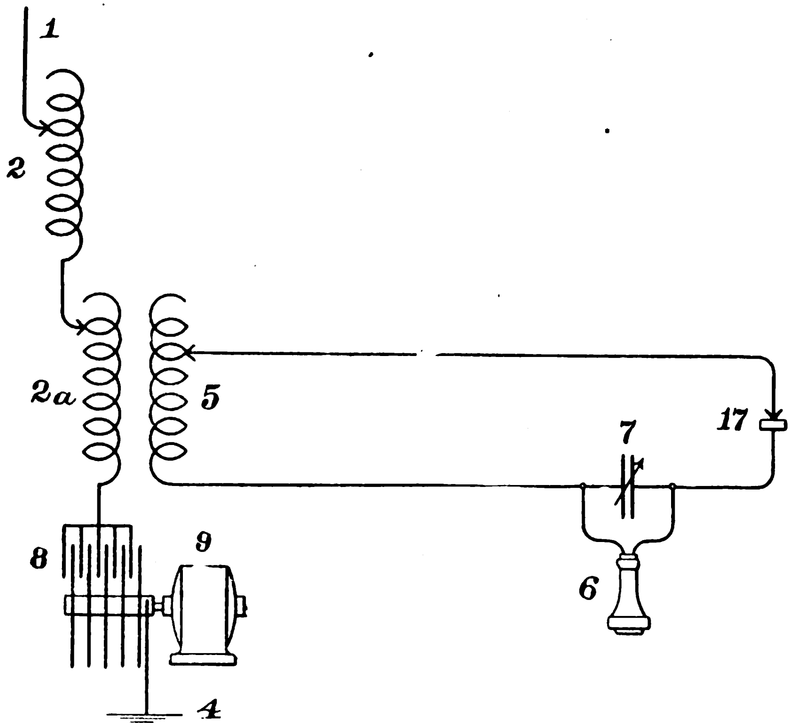


Figure 4

The novelty of the system disclosed by the inventor lies in the use of a rotating condenser of variable capacity which is placed in various positions in the receiving circuit to vary the amplitude of the incoming oscillations. One method of connection is shown in Figure 2, where the condenser is placed in shunt to the secondary winding of a receiving tuner. If the value of the secondary inductance, 5, is properly adjusted so that at a certain position of the revolving condenser, 8, the circuit is in resonance with the incoming oscillations, current will flow periodically through the crystal rectifier, 17, charging the condenser, 7, which discharges through the head telephone, 6. If the condenser, 8, is of such construction, or revolves at such speed, that the secondary circuit is thrown into resonance with the antenna circuit, say, 500 to 750 times per second, a very clear tone will be obtained in the receiver, 6. If condenser 8 is stopped at the required value of capacity, the circuit will respond to discontinuous waves as well.

Other arrangements of this circuit are shown in Figures 3, 4 and 5. The circuit shown in Figure 3 is of particular interest owing to its simplicity. Very good results have been obtained in the reception of undamped oscillations. A point of interest in connection with the operation of this device is this: if the receiving circuit is thrown in resonance by the rotating condenser at any other position than that of the maximum capacity of a particular set of plates, the circuit will be thrown into resonance twice for each set of stationary plates; once when the position of maximum capacity is approached and again when the position of maximum capacity is passed.

An Oscillation Generator for Radio Telegraphy

A METHOD for generating practically continuous oscillations from a source of direct current recently described by R. Heising is shown in Figure 6, the principal point of departure from common oscillating generator systems being the lack of a spark or arc gap.

The objects of the inventor's device are accomplished by means of two

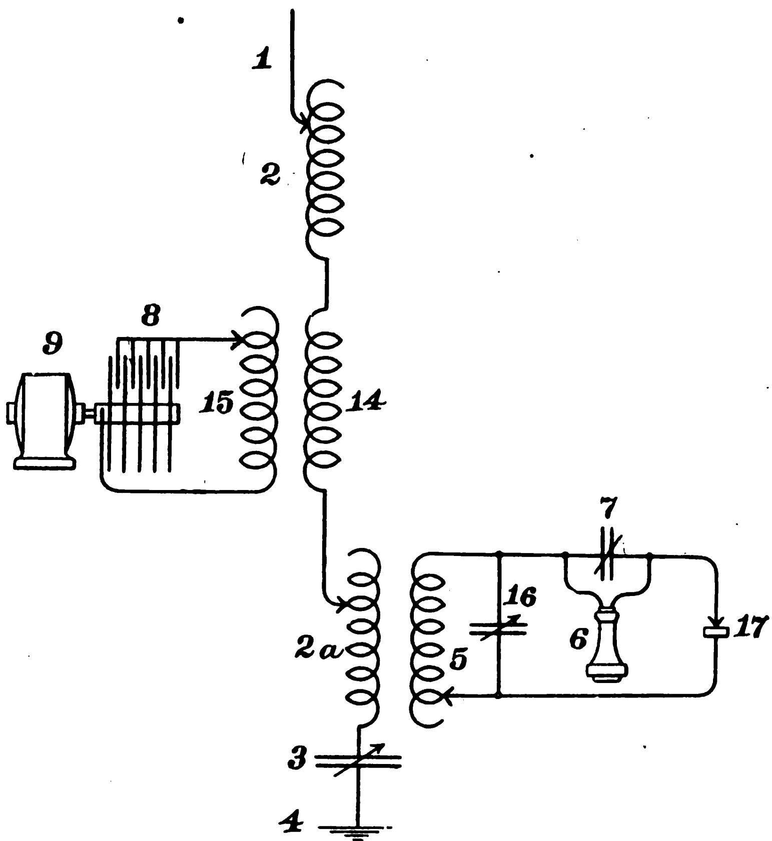


Figure 5

rotatable discs, 22, with the contact studs, 4, which make connection with the brushes, 6. An oscillation circuit consisting of the condenser, 7, and the coil, 8, is shunted directly across the two discs and the coil, 8, is in turn inductively coupled to the coil, 9, which is part of the antenna circuit, 10. A driving motor is shown at 11 and an alternator at 12 for keeping the device rotating at a constant speed.

The operation of the system is described as follows:

At the instant at which the brushes, 6, make contact with a pair of studs, 4, a rush of current from the generator takes place, which charges the condenser, 7, to a voltage equal to that of the generator. The contact is immediately broken with the discs, and the condenser discharges through the inductance coil, 8. Oscillations are therefore set up in the circuit, 7, 8, and after the lapse of a time equal to one cycle, the condenser 7 will again be charged to approximately its original potential difference, the actual value being slightly less than the original because of the damping of the oscillations. If at this time the brushes, 6, again make contact with a pair of studs, a sudden rush of current will take place from the

generator and renew the charge on the condenser to its original value. Since, however, the loss of charge in the condenser during one cycle is relatively small, the potential difference between the brushes and the discs at the end of the first

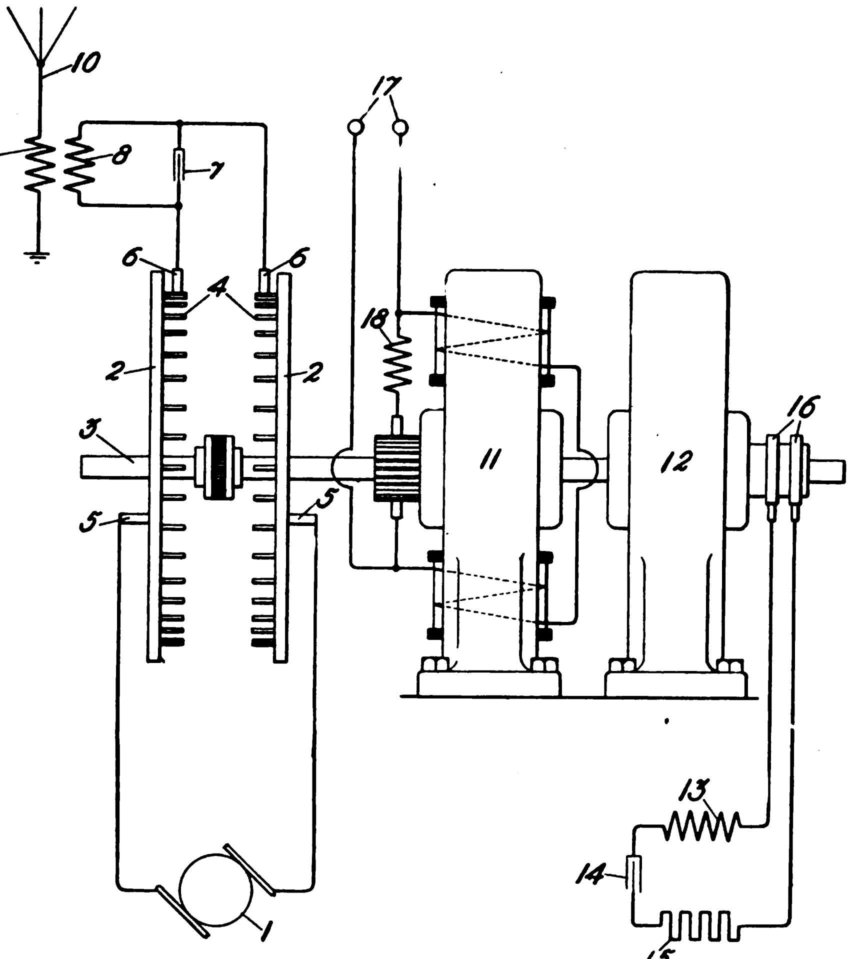


Figure 6

cycle will also be relatively small; therefore the transfer of power may take place without heavy sparking at the studs when the contact is broken.

The arrangement for maintaining the speed of these discs constant is of unusual interest. A regulating resistance, 18, is connected in series with the motor armature and the effect upon its operation is to lower the effective voltage over the terminals of the motor as the load increases. A resonant circuit, 13, 14, 15, is shunted across the collector rings of the alternator. If it is tuned to a frequency slightly higher than that which would be developed were the alternator running at the speed required for operating the contact-making device, and if for any reason the speed of the alternator increases, a larger current will be set up in the resonant circuit which will consequently increase the load upon the alternator, 12, and therefore on the motor, 11; but the effect of this increase in load is to lower the effective voltage over its terminals and the speed of the shaft will therefore tend to fall to its original value. On the other hand, if the speed of the motor is decreased the frequency developed by the alternator will depart still more from that required for resonance and therefore the load on the generator and motor will decrease. Consequently the voltage on its terminals will increase and the speed will tend to rise again to its correct value.

Signal Officers' Training Course

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

SEVENTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Radio Apparatus of the Signal Corps

TWO types of portable field sets have been issued by the Signal Corps. The smaller size, known as a field radio pack set, is furnished to the Organized Militia as well as to the field companies. The range of these sets under normal conditions is about 25 miles over land, but much greater over water. Thus one of the one-eighth kilowatt sets, with a hundred-foot mast, at Habana has worked with the naval station at Key West, a distance of about 110 miles.

The larger size of field sets, known as a wagon set, is of 2-kilowatts output and is carried on a two-chest pintle wagon, one chest with the engine and generator and the other with the transmitting and receiving apparatus. The range of these sets varies from 75 to 800 miles, depending on favorable weather conditions, time of day or night, character of the land between the sets, and similar conditions.

Field Wagon Sets

The following are general instructions for the operation and care of the two-wagon 2-kilowatt set:

Engine.—The engine supplied with this set is a water-cooled, single-cylinder gasoline engine with a normal speed of 1,500 R. P. M., and the same general directions as to care and operation which apply to water-cooled gasoline engines

in general apply in this case, and the principal points are briefly as follows:

Before starting make sure—

1. That the tank is full.
2. That all bearings have been oiled.
3. That the engine has sufficient lubricating oil by means of the stopcock on under part of crank case. If it drips when opened, there is sufficient oil.
4. That there is sufficient gasoline in the tank as indicated by the guage on the front of the tank.
5. That the main switch of the generator is open.

To start—

1. Open gasoline feed cock.
2. Prime carburetor by plunger on top.
3. Set the governor control handle (just above the crank) vertically, i. e., halfway across the scale.
4. Set the spark-control lever on the magneto on bottom notch.
5. Crank.

After starting—

1. Make sure that the fan is running.
2. Close main switch.

Speed: The speed, as indicated by the tachometer on the engine, is controlled by the position of the governor control handle (directly over the crank) and by the position of the spark control lever on the magneto (at the right), and the best position of each for any particular speed is best and easily determined by experiment.

To shut down temporarily—

1. Open main switch of generator.
2. Press button on front of magneto until engine stops.

To shut down permanently—

1. Same as above.
2. Ditto.
3. Turn off gasoline.
4. In cold weather empty all water out of every part of cooling system by means of the cocks provided for that purpose.

Generator.—The alternating-current generator supplied with this set is of the inductor type with the field and armature winding stationary, and has therefore no brushes or sliding contacts of any kind. Its normal voltage is 85. The exciter is an ordinary low-voltage direct-current machine. The voltage of the alternating-current generator is varied by means of the rheostat in series with its field. The rheostat is located in the lower left-hand corner of the front part of the instrument wagon. The connections between the power wagon and the instrument wagon are made by means of a flexible armored four-conductor cable having the sockets so arranged that the terminals can be inserted only in the proper manner, the circuits of the alternator, exciter, etc., being shown in figure 3.

Transmitter and receiver.—The connections of both are clearly shown in the drawing and require no further description.

To adjust the transmitter for any wave length within the range of the set proceed as follows, assuming that the desired wave length is 1,000 meters:

1. If it is intended to send at full power, adjust the voltage of the generator by means of the slide rheostat (at the left) to about 85 volts.

2. If it is intended to send at less than full power, short-circuit one or more of the gaps by means of the clips provided and at the same time reduce the generator voltage about 10 per cent per gap short-circuited.

3. Set the primary variometer (at the left) at the wave length desired, viz., 1,000.

4. Put the aerial-coil plug (at the right) in hole No. 1, marked 680/1050. This adds sufficient inductance to the aerial to bring the final adjustment within range of the aerial variometer.

5. Make the final adjustment with the aerial variometer (also on the right and on one side of the aerial coils) by turning it slowly up from zero until the ammeter in the aerial or ground circuit indicates a maximum.

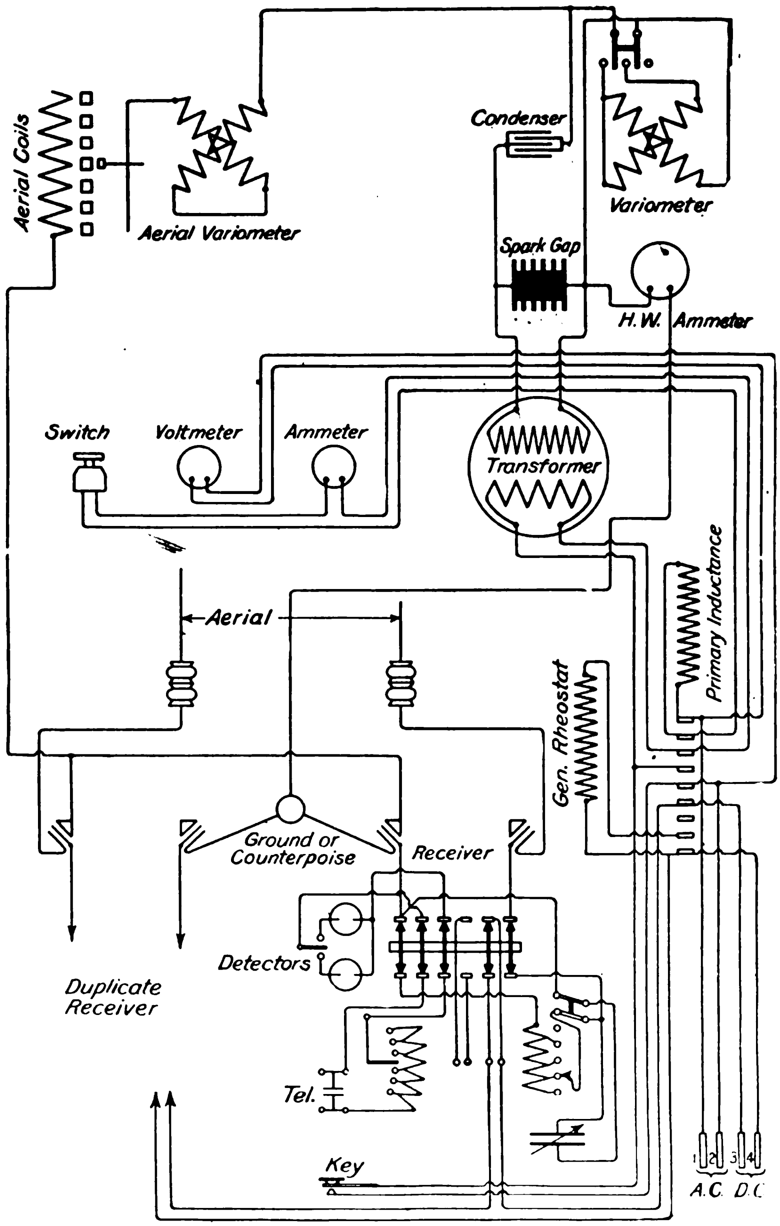


Figure 1—Connections of the 2-kilowatt field wagon set of the Signal Corps

6. The transmitter is now adjusted for the most efficient production and radiation of the wave length selected when used with the aerial and counterpoise supplied with the set.

Receiver.—To receive, close the large double-pole switch at the top of the receiver.

The plug holes marked with Roman numbers (at the right on the receiver) are connected to taps on the aerial or primary coil. The wave range of this coil is approximately as follows, with a proper aerial:

Plug.	Condenser switch at— Short Waves.	Condenser switch at— Long Waves.
	Meters.	*Meters.*
I	260-400	500-600
II	310-510	640-910
III	370-730	900-1,410
IV	540-1,060	1,270-2,150
V		1,860-3,080
VI		2,700-4,000

The turns on the detector or loose coupling coil are variable by means of the switch located on its top, the wave range for each tap being marked.

Either of the two detectors can be used by means of the switch located between them.

For receiving a signal of a known wave length the following procedure can be recommended:

1. Use tight coupling.
2. Plug in on the aerial coil.
3. Set the switch on the detector coil at about "λ—500-1000."
4. Turn the condenser very slowly over the entire scale.
5. Change the plug on aerial coil and repeat No. 4. When signals are finally heard, the coupling and the position of the switch on the detector coil are varied until the best results are obtained.

NOTE.—In some cases two combinations of the aerial plug and condenser give almost equally good results. The best one is that in which the larger part of the condenser is used with condenser switch at "short waves" and vice versa, with the condenser switch at "long waves." The aerial used with this set should have a capacity of 0.0011 mf and a natural period of 450 meters.

The following detailed notes on the circuits and operation of the set have been found useful as a result of actual work in the field:

Power Circuits

Referring to connection diagram figure 1, it is seen that D. C. leads marked 3 and 4 go to both receiving switches in series. It is therefore necessary to have the main switches of both receiving sets in the same position—that is, cut off—when sending, even though one receiving set may have no aerial wire connected to it. A flash due to the breaking of this D. C. circuit will be seen at the rotary switch if the receiving set is cut in before the engine is stopped. The large double-pole switch at the top of the receiver when closed so as to connect the receiver to the aerial and counterpoise automatically disconnects the sending side from the aerial and counterpoise. This feature is not indicated in the diagram of connections where the receiving set when cut in is apparently shunted by the sending set.

Transformer Primary Circuit

From A. C. lead No. 1 to the primary inductance, to the snap switch, to the ammeter, to the primary of the transformer, to the key, and via A. C. lead No. 2 back to the generator. The voltmeter is across the A. C. leads as shown. If the voltmeter shows voltage, but upon closing the key no spark takes place at the spark gap, the snap switch in the primary circuit is probably open.

The voltage, as indicated by the voltmeter, must never be more than 85. If it is desired to change the generator frequency (and the pitch of the note

emitted), in order to secure greater selectivity for the set when working in the presence of other sets having about the same generator frequency, the engine may be slowed down or speeded up, but the drop or rise in voltage incident thereto must be compensated for by a change in the generator rheostat, so that the voltage will be kept constant at 85 when using all the gaps at the spark gap. *Any violation of this rule will cause a breakdown in the transformer.*

High-Frequency Circuits—Transmitter

Closed oscillating circuit.—This consists of the condenser, variometer, and spark gap. It is to be noted that the variometer is common to both closed and open oscillatory circuits, and, therefore, that changing the variometer (which is the one at the left-hand side of the chest and has scale divisions in wave lengths marked upon it) not only changes the period to which the closed oscillatory circuit is tuned, but also slightly changes the tuning of the open oscillatory circuit. A

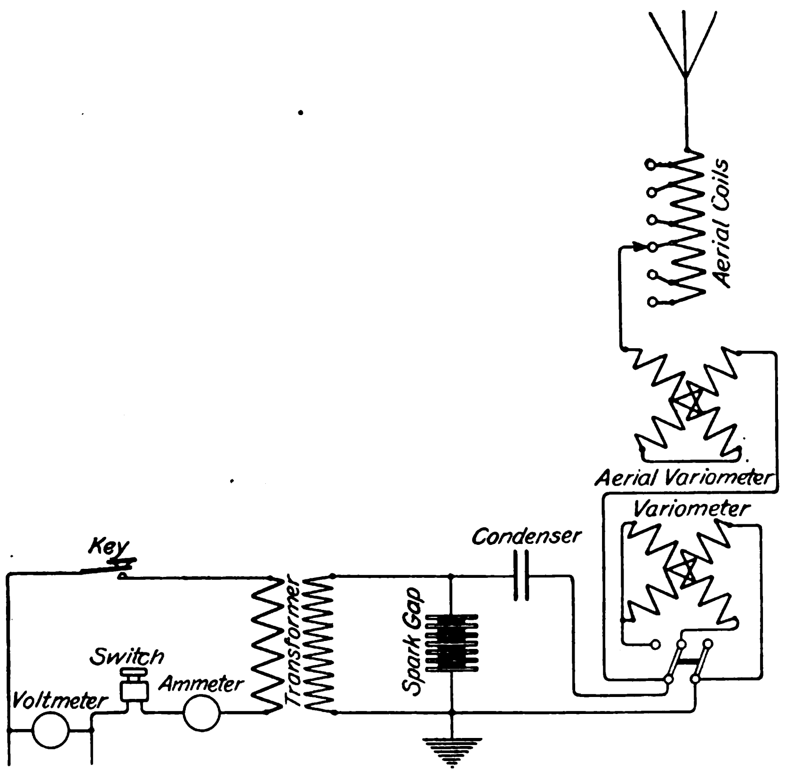


Figure 2—Simplified diagram of transmitting circuits

word of caution should be given concerning the switch marked "Little" and "Great" which throws the coils of this variometer from a parallel to a series connection or vice versa. This switch can only be moved to the right or left—to "Little" or to "Great"—when the index is directly opposite the dividing line between the red and the white divisions. *Any attempt to throw the switch when the variometer coils are in any position will only result in damage to the switch.*

Open Oscillatory Circuit

This consists of the aerial, aerial or loading coils, plug for cutting in proper coil, the aerial variometer (marked from zero to 180°), the variometer common to both closed and open oscillatory circuits, the hot-wire ammeter, and the counterpoise or ground.

The antenna supplied by the Signal Corps for this set has a natural wave length of 450 meters and a capacity of about 0.0011 mf.

It is found by experiment that the set using the Signal Corps 80-foot mast and rubber-covered counterpoise works best at about 1,000 meters, where the antenna hot-wire ammeter reads about 7¼ amperes.

Coding of Wave Lengths

The great advantage of this set lies in the fact that any desired wave length from 675 to 2,220 meters can be sent out at will and if the wave length is changed after every word of a message, according to a prearranged code of wave lengths—for example, the first word sent with 700 meters, the next with 2,100, the next with 1,400, etc.—it will be difficult for any eavesdropping operator who has not the wave-length code to follow the changes of wave length with any success. Hence, messages may sometimes be kept confidential even when sent in plain English. This will take considerable drill on the part of two men, the operator and an assistant, who will rapidly make the necessary changes in the loading coils and variometers at a signal from the operator.

The fist step will be to make experimental determination of the combinations of loading coils and variometers necessary to produce the best radiation for every wave length, within the range of the set and to set them down in the form of a table. Thus, starting with 700 meters, put the left-hand variometer at 700, put the plug in the hole marked 675-1,080, and then slowly move the aerial variometer from 0° toward 180° until the hot-wire ammeter shows the best reading. The various adjustments can then be noted in a table for future reference, thus: (The figures given are not the actual figures. These must be determined for each set separately.)

TABLE I.

Wave length.	Variometer.	Loading coil.	Aerial variometer.	Amperes on hot wire.
700	700	675-1,080	12	6.9
750	750	675-1,080	20	6.95
800	800	675-1,080	50	7
850	850	675-1,080	80	7.05
900	900	675-1,080	120	7.1
950	950	920-1,310	4	7.15
1,000	1,000	920-1,310	10	7.25
1,050	1.050	920-1,310	60	7
1,100	1,100	920-1,310	90	6.8
1,150	1,150	920-1,310	105	6.6
1,200	1,200	920-1,310	130	6.4
1,250	1,250	1,240-1,510	5	6.2

and so on, finding the best combination for every 50 meters increase in wave length up to the limit of the set.

Limitations of System of Coding Wave Lengths

It will be noted that there is one best wave for the set, namely, about 1,000 meters. From some experiments made recently at Fort Leavenworth it is concluded that it is safe to state that, up to about 75 miles over average land, the falling off of energy due to the use of the longest wave lengths will not be so great as to prevent the use of any wave length within the limits of the set (675-2,220 meters), but that beyond that distance, up to the extreme daylight distance of the set (about 185 miles), it would be safer not to work with any wave length greater than 1,800 meters.

Only further experiments in the field, between two similar sets working at gradually increasing long ranges, will determine the greatest distance at which the whole scale of sending wave lengths may be used.

From the table plotted, different codes of wave lengths, differing by

many meters from each other, may be agreed upon, to be changed daily in actual work, and confided to all operators concerned.

Receiving Circuits

Primary or aerial circuit.—One lead from aerial comes through combination switch to the primary of the transformer (shown on the left of figure 4), from there through plug contact to a point on the little switch marked "Long waves"-"Short waves"; and, if the switch is thrown to the long-wave side, the circuit goes direct to the ground; the variable condenser being then in parallel with the primary of the transformer. If the switch is thrown to the short wave side, the variable condenser is in series with the aerial, the primary of the receiving transformer, and the counterpoise or ground.

The secondary or detector circuit consists of the secondary of the transformer in series with the usual stopping condenser, connected through the main switch to the detectors. The telephones are in shunt to the stopping condenser.

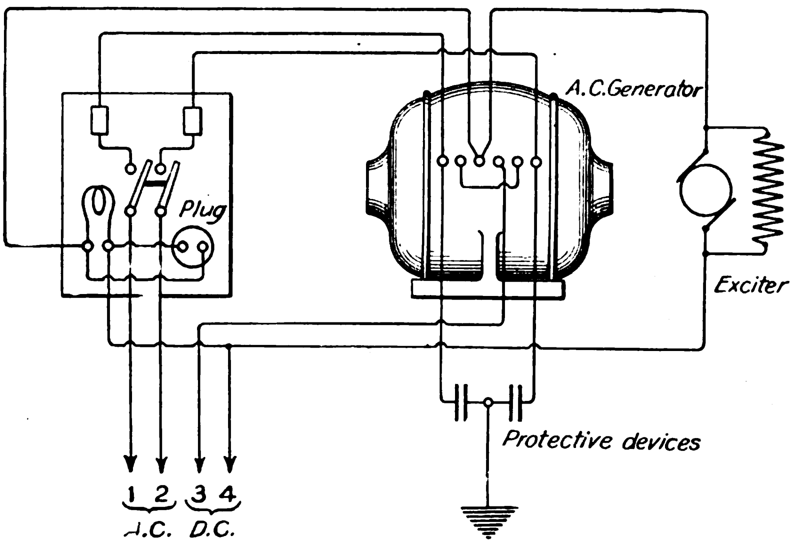


Figure 3—Generator circuits

The detector supplied is of the iron pyrites variety, which lacks the sensitiveness of the Perikon. Any other detector may easily be substituted for the detectors supplied with the set, the range of which may be thereby easily increased.

With the switch thrown to "Long waves" the operator will get the best results when using a small number of degrees of the variable condenser and as large primary as possible, and, vice versa, with the switch to "Short waves," which places the variable condenser in series with the primary coils. The largest possible amount of capacity of the variable condenser and the smallest amount of primary inductance should be used for maximum strength of signals.

The combination switch which is used primarily to cut the receiving set onto the antenna and counterpoise simultaneously performs several operations. Opening this switch disconnects the receiving set from the antenna and counterpoise; automatically connects sending set to the aerial and counterpoise; closes D. C. circuit of generator; disconnects detectors from secondary of receiving transformer, thus opening that circuit and preventing detectors from being affected by the spark when sending, and also opens the primary circuit of the receiving transformer. As the limits of the various coils

of the primary and secondary are marked, there should be no difficulty about setting the receiving apparatus approximately for the wave length of a station whose wave length is known. The operator then varies his condenser, and also the coupling between the primary and secondary of the receiving transformer, until he gets the best adjustment. Changing the coupling (that is, pulling the secondary away from or pushing it closer to the primary) changes the wave length, though to not as great an extent as does varying the condenser. Some stations can not be heard at all well unless the secondary coil is pulled some distance away from the primary. Practice is the best guide to a working knowledge of the tuning of the receiving set.

Figure 2 shows simplified schematic diagram of the transmitting circuits. Figure 3 shows the generator circuits.

Calibration in Wave Lengths

The receiving set should be calibrated so as to locate the actual combinations necessary for receiving the wave lengths sent out by a similar sending set either by actual tuning to another set sending out successive wave lengths

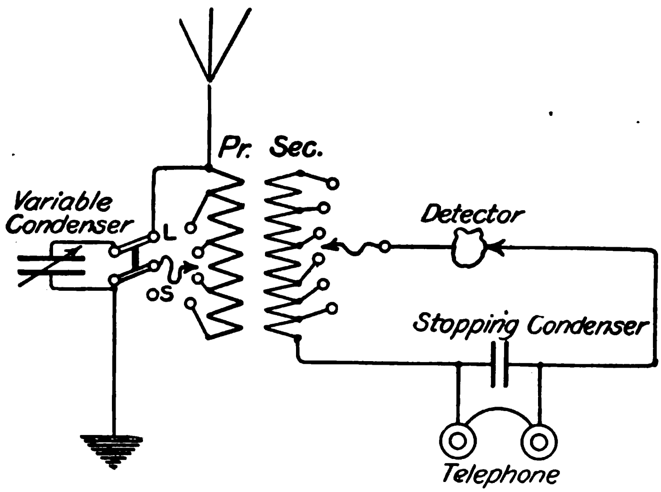


Figure 4—Receiving circuit

differing from each other by 50 meters, as outlined, or by using the wave meter provided with each wagon set as a sending device, and with its coupling coil held near the antenna lead, set up, consecutively, different wave lengths in the antenna and make adjustments of receiving set necessary to tune to the particular wave lengths sent out; then compile a table showing adjustments of condenser switch, primary, secondary, and variable condenser necessary for each wave length in turn, so that the receiving operator can at once adjust his receiving apparatus to any desired wave length, and, by quick changes, constantly follow, according to prearranged code, the message sent out by the other station.

It is recommended that, in order to eliminate one adjustment of the receiving set, the primary and secondary of the receiving transformer be kept in the same relative positions throughout; that is, as close to each other as possible. This, while possibly sacrificing efficiency, secures simplicity. The receiving operator's chart may be arranged as follows:

Best receiving adjustments necessary to tune to wave lengths used by similar wagon-set sending wave lengths shown in Table I.

TABLE II.

Wave length.	Switch.	Primary.	Secondary.	Condenser.
700	Short waves........	370-730	500-1,000	80°
750	Long waves........	640-910	500-1,000	40°

And so forth for every 50 meters.

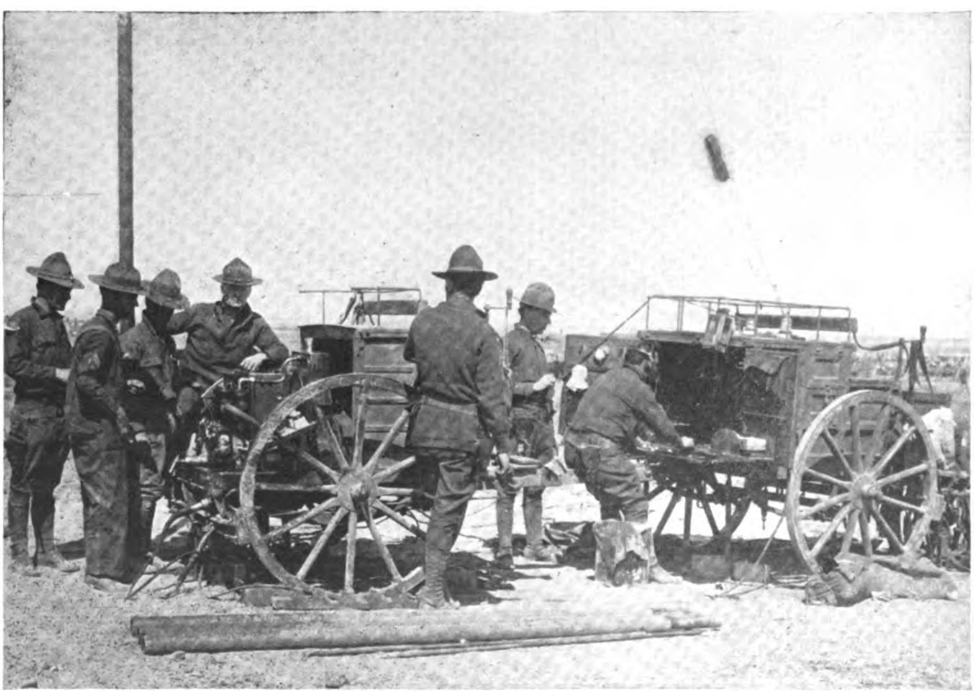
NOTE.—The condenser adjustments given above are not the actual ones necessary for wave lengths given.

Constant drill in changing sending and receiving adjustments, carried on between two or more similar sets, will result in remarkable efficiency and rapidity, and the time necessary for transmission of messages will be found to be but little increased over that required when sending on a single wave length.

Receiving by Coding of Wave Lengths

Two complete receiving sets are provided with each wagon set, though ordinarily only one is used. Two messages from different stations may be copied from the same antenna without either operator hearing the message copied by the other. To do this it is, of course, necessary to have a lead from the aerial running to each of the receiving sets. A change in the tuning of one receiving set will call for a slight readjustment of the other receiving set, however, in order that the latter may stay in tune with the given wave length.

The use of two receiving sets in parallel makes it comparatively simple to follow a message sent according to a prearranged code of wave lengths, for it is perfectly practicable to so arrange the wave-length code that the waves of any length within certain limits will fall within the limits of the condenser of either one set or the other, and either one operator or the other, without making any change of adjustment other than a mere movement of



Field wagon radio set, U. S. Army, set up and working

the condenser handle, will have his apparatus constantly in resonance with the incoming waves.

Thus, let us say that in the code agreed upon, which includes all wave lengths between 900 and 2,150 meters, the first word will be sent with a 900-meter wave, the next with 2,100, followed by 1,500, 1,850, 1,050, 2,000, etc.

The two sets are cut in at the receiving station and are each manned by an operator. Operator No. 1, at the left, puts the plug in the hole of the primary of his receiving set marked "900-1410," couples his primary and secondary as closely as possible, throws his receiving switch to "Long waves," and puts the switch of the detector coil on whatever coil will give him the strongest signals. He can then, by merely moving the condenser from 0° toward 180°, tune his set to any desired wave between 900 and 1,410 meters, and it will be his duty to copy all words of the message which may fall within those limits.

Operator No. 2, on the right, similarly throws his switch to "Long waves" and plugs in primary coil marked "1270-2150," and makes the other adjustments as given for No. 1. He is then ready to receive any wave between 1,270 and 2,150 meters by merely setting the pointer of his condenser at the proper number of degrees on the condenser.

From Table II, prepared as before described, either operator can set his condenser accurately and instantly to the proper reading for any desired wave length within limits; hence when the message is to be received the first word sent as per schedule at 900 meters is copied by No. 1 operator, who has his pointer at the proper place on the condenser scale; the second word at 2,100 meters by No. 2, who has already set his pointer at the proper place. As the third word is sent at 1,500 meters, No. 2 readjusts his condenser for the next word, and later turns the pointer to the proper place for the next word at 1,850; then No. 1 comes in on his set and copies the next word at 1,050 meters, No. 2 the next at 2,000, and so forth, the words being placed together in accordance with the order of their receipt so as to make a complete message.

This method of using two operators saves time by dispensing with a number of switch and plug changes, which a single operator would have to make in using only one receiving set.

The method of using two receiving sets tuned as described could easily be worked by one operator who could wear the single head receiver of one set on one ear and that of the other on his other ear.

All these methods should be practiced continually to improve the skill of the operators.

Care must be taken to close or open both main switches of the receiving set at the same time when working both receiving sets in order to prevent sending into one of the receiving sets and burning it out.

"Mailed by Wireless"

A WOMAN resident of Paris, Ill., is in receipt of a post card which was "mailed by wireless," by her brother, a member of an Ohio regiment of engineers which has landed safely in France.

The mailing of the card was accomplished in the following manner:

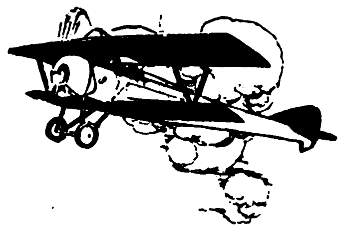
Before boarding the ship which was to take them abroad, many members of the regiment wrote post cards, announcing their safe arrival in France. These cards were held by the postal authorities of the Government, pending further instructions.

Upon the arrival of the regiment in France, a wireless message was sent to this country announcing the fact and the Post Office forwarded the cards to their destinations.

In this way the worry and anxiety incidental to sending letters across the Atlantic in these troublous times was avoided.

How to Become an Aviator

The Fifth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

MAINTENANCE of aeroplane equilibrium is secured by (a) features of design, (b) controls operated by the pilot.

The following factors of stability and control are to be considered:

(1) **Stability**—The natural tendency of a body disturbed to return to normal position.

(2) **Longitudinal Stability**—The tendency of an aeroplane to maintain stability along the direction of normal horizontal flight and overcome pitching and tossing.

(3) **Lateral Stability**—The tendency to oppose rolling sideways.

(4) **Directional Stability**—The tendency to oppose swerving to the right or left of its proper course.

In dealing with these factors, one must dispose of the popular misconception that stability is fixed "steadiness" in flight, attained through skillful design. While it is not easily capsized, an inherently stable aeroplane does not respond readily to its controls; it is sensitive to all air disturbances and will roll and sway in response to air billows, whereas one of neutral stability answers its mechanical and automatic controls handily, and because it has no inherent tendency to hold a fixed position relative to the air, adjusts itself easily so that its position relative to the ground is not changed by air disturbances.

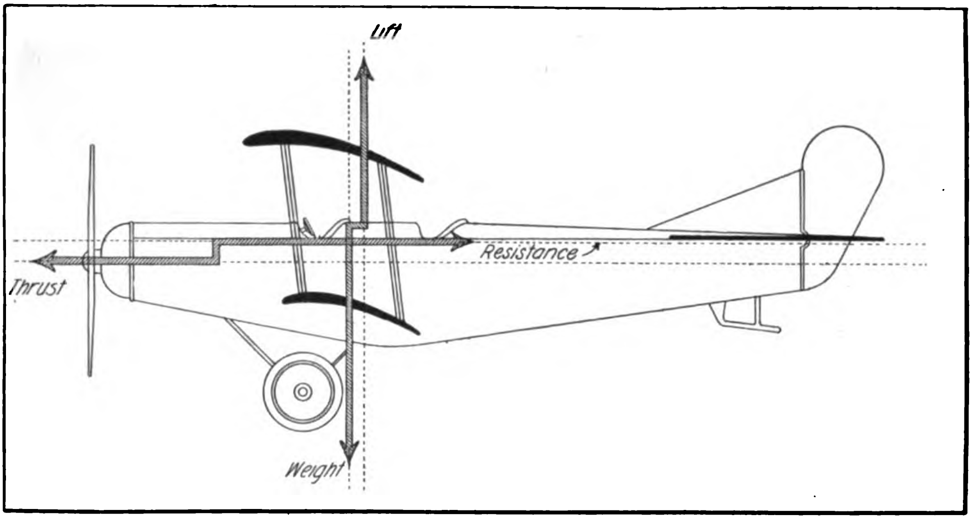


Figure 14—Balance of forces for aeroplane equilibrium.

CENTER OF GRAVITY

The first consideration of aeroplane stability and general flying efficiency is the center of gravity, for the craft is suspended in the air and rotates about this point. The proper place for its location is where the forces of thrust, resistance, lift and weight act.

Ordinarily, the aeroplane is so designed that the thrust line passes nearly through the center of resistance, and the center of gravity is made in line with the weight and lift.

See figure 14.

The center of thrust is often placed below the center of resistance, for convenience. In pusher types the thrust is sometimes above the line of resistance. The tendency to nose down thus produced is overcome by having the center of lift back of the center of gravity. The principle of coincident centers is the factor of proper balance, but with variations in the position and strength of these forces produced in flight, the balance is restored by small forces, such as the tail of the aeroplane.

If the center of gravity is too low it produces a pendulum effect and causes a sideway roll of the aeroplane. When too high, if disturbed it seeks a position as far as possible from the original, tending to tip over the aeroplane.

METHODS OF DETERMINING THE C. G.

(a) Point of balance may be determined by placing a roller under the aeroplane.

(b) The aeroplane swung from a point overhead and a plumb line dropped from this point.

(c) With the machine supported at front and rear, the weight at each point determined and the distance between the two points measured. This is known as the method of moments.

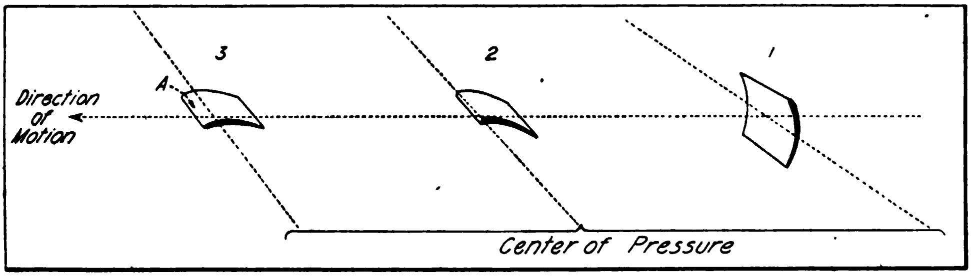


Figure 15—*Instability of cambered surfaces*

Longitudinal Stability

LIFTING SURFACES

Cambered wing surfaces are longitudinally unstable at angles of incidence below 12 degrees, at which angles fair lift-drift ratio is produced.

In figure 15, the centers of pressure of surfaces 1, 2 and 3 are indicated. The C. P. is the point at which all the air forces about balance.

Surface 1 is cambered and in a position approximately vertical, moving in a direction from right to left. Its center of pressure is along the exact center line of the surface.

With decrease in angle to one of about 30 degrees, the center of pressure moves forward to the position shown in Surface 2.

In Surface 3 the angle of incidence has so decreased that there is a downward pressure at point A. Corresponding depressions in such negative angles increase proportionately the pressure A. The center of pressure being the resultant of all air forces, it is affected by the downward pressure at A and moves backward. This pushes up the rear of the surface and increases the tendency to dive. But as the surface's angle of incidence is increased the pressure at point A decreases, whereupon the center of pressure moves forward and pushes up the front. If the angle is thus greatly increased the result is a "tail slide."

STABILIZING SURFACE

Since the cambered wing surface is inherently unstable, a stabilizing surface at some distance in the rear, or at the tail, is added. This tail surface has less angle of incidence.

Figures 16a, 16b and 16c illustrate the effect of the tail surfaces, the upper portions of the drawing showing main lifting surfaces at varying angles, and with tail attached in lower view.

In figure 16a, the lift force is in rear of the center of gravity, which tends to make the wing dive; in the lower view it is shown how the downward pressure on the tail counteracts this tendency.

Figure 16b shows a surface with lift passing through the center of gravity. The wing is therefore balanced and tail pressure is not needed unless a sudden change in angle is effected.

In figure 16c the line of lift force is ahead of the center of gravity. The tendency of the wing to rear up is here offset by the upward pressure on the tail, as shown in the lower view.

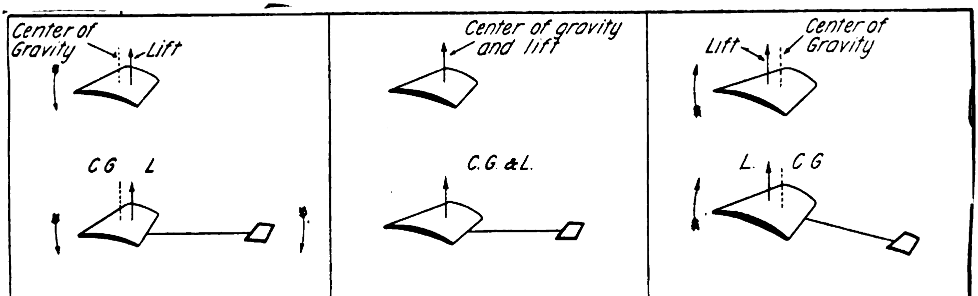


Fig. 16*a* *Fig.* 16*b* *Fig.* 16*c*

Balance of lifting surfaces by tail stabilizer.

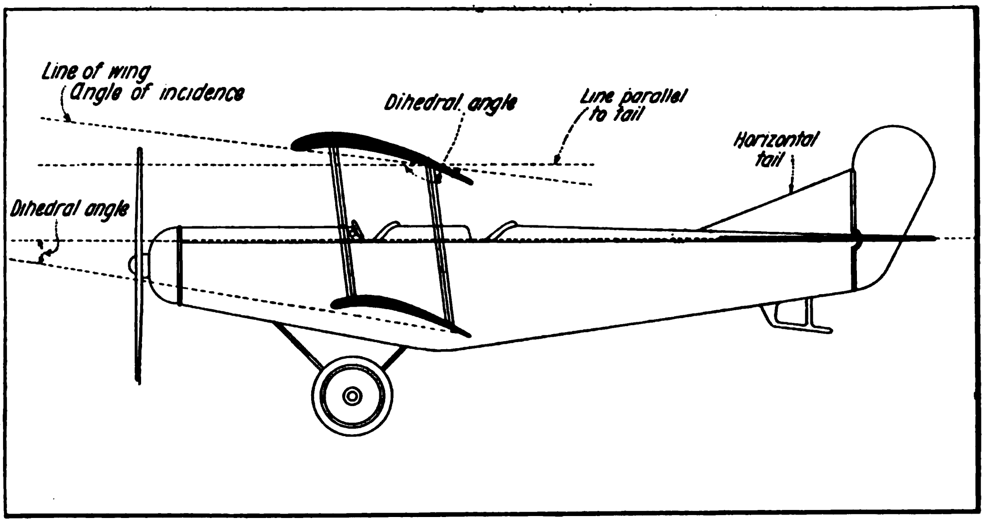


Figure 17—Dihedral angle formed by lifting surfaces and stabilizer

LONGITUDINAL DIHEDRAL ANGLE

The tail must have an angle of incidence smaller than that of the wings. The angle of incidence of the tail stabilizing surface is ordinarily about one-third of the aerofoil angle. The neutral lift lines of each, when projected to meet, make a dihedral angle.

See figure 17.

Occasionally, the tail-plane's angle is the same as that of the main lifting surfaces, the lessened angle of incidence required of the former being secured by the downward deflection of air from the upper aerofoil.

To illustrate the effect of stability secured by the longitudinal dihedral, we may consider an aeroplane traveling a horizontal course; in this position the thrust and direction of motion are identical. The nose of the machine then being suddenly deflected by some air disturbance, the angle of incidence is changed with the downward position. Assume that on the horizontal course the aerofoil angle was 12 degrees and with the deflection the thrust line is lowered, say, 3 degrees. **The angle of incidence is not changed in the same proportion,** because the **momentum** of the former (horizontal) course pulls it off the direction of thrust.

The net change of angle of incidence will be assumed to be 2 degrees. Both main lifting surfaces and tail stabilizer are affected by the change because both are fixed to the aeroplane structure. Both have decreased, proportionately. The main lifting surfaces, with former angle of incidence at 12 degrees, have decreased to 10 degrees. The tail stabilizer, with former angle 0 degrees, has now a **minus** angle or negative of 2 degrees. Therefore, since the main surfaces have lost 12°—2°, or 1/6 of their lift, and the tail stabilizer is now at an entirely negative angle, the tail will fall faster than the main planes. The aeroplane in consequence rights itself, or readjusts to the former horizontal.

The reverse happens when the nose of the machine is tilted up by a gust of wind. While both main lifting surfaces and tail surface increase angles of incidence in the same amount, the angle (which determines the lift) increases in **greater proportion** with the tail than with the main surfaces, which lifts the tail faster. The aeroplane then assumes its first position at a slightly greater altitude.

The variation of angle of incidence is not as great as the variation of the aeroplane's angle to the horizontal.

Stability produced by the effect of the longitudinal dihedral exists only when there is momentum in the original direction.

The stability adjustments described are taking place almost continuously in flight, although not always perceptible to the aviator.

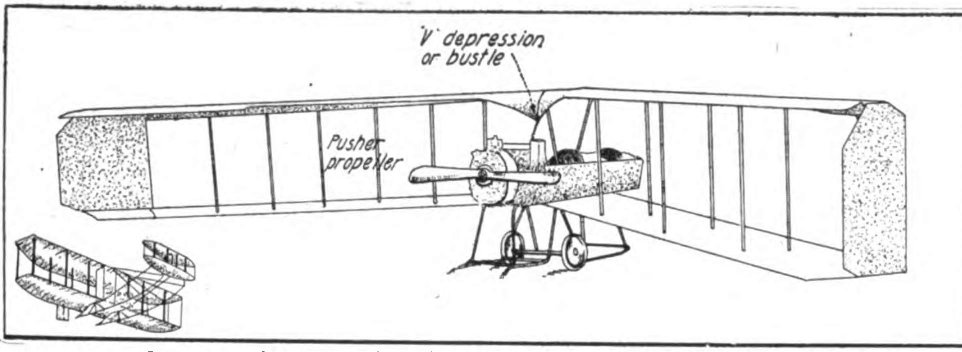


Figure 18 *Figure 19—Aeroplane of the Dunne type, with longitudinal dihedral surfaces*

CANARD PRINCIPLE

In early types, such as shown in the lower left of the drawing on this page, figure 18, it was customary to place the stabilizing surface in front. The tail-first principle possessed obvious disadvantages, notably that sufficient longitudinal stability could be had only by giving this a greater angle of incidence than the main lifting surfaces. Thus if the wings had an angle of 5 degrees, the forward stabilizer was set at an angle of incidence of 15 degrees, which gave poor lift-drift ratio at high speeds.

Low velocities were the rule in the early days and the defect in design was not appreciated until increased speeds were required. The principle of the forward stablizer, known as the canard, is now obsolete.

MAIN SURFACE DIHEDRAL

Figure 19 shows a view of the Dunne aeroplane, from the right rear. This type has no stabilizing tail surface, longitudinal dihedral being given by the main surface having a decreasing angle of incidence toward the wing tips and corresponding camber. The theory is that the wing tips act as longitudinal stabilizers.

This design has the following disadvantages:

(a) Departure from the usual form of lifting surfaces, in plan a parallelogram, is a mechanical inferiority, requiring additional strength of construction. This increases weight.

(b) Aspect ratio is lowered because the leading edge of the aerofoil is not at a right angle to the direction of motion. Lift is lessened on account of lowered aspect.

(c) Drift is increased by the action of the air on the V-shaped depression in the center of the aerofoil. This dip is pointed in the direction of motion and when the aeroplane is turned off its course to a direction which is the resultant of thrust and momentum, or a sideways motion, the air pressure on the corresponding side of the V depression turns the machine back on its course. It is obvious that the air reaction set up by this depression increases drift.

(d) The necessity for decreasing the angle and camber toward wing tips increases time and cost of construction.

Vertical surfaces at the wing tips, as shown in the drawing, are sometimes added, set at an angle producing the same stabilizing effect. Drift is increased by this arrangement, and efficiency lowered.

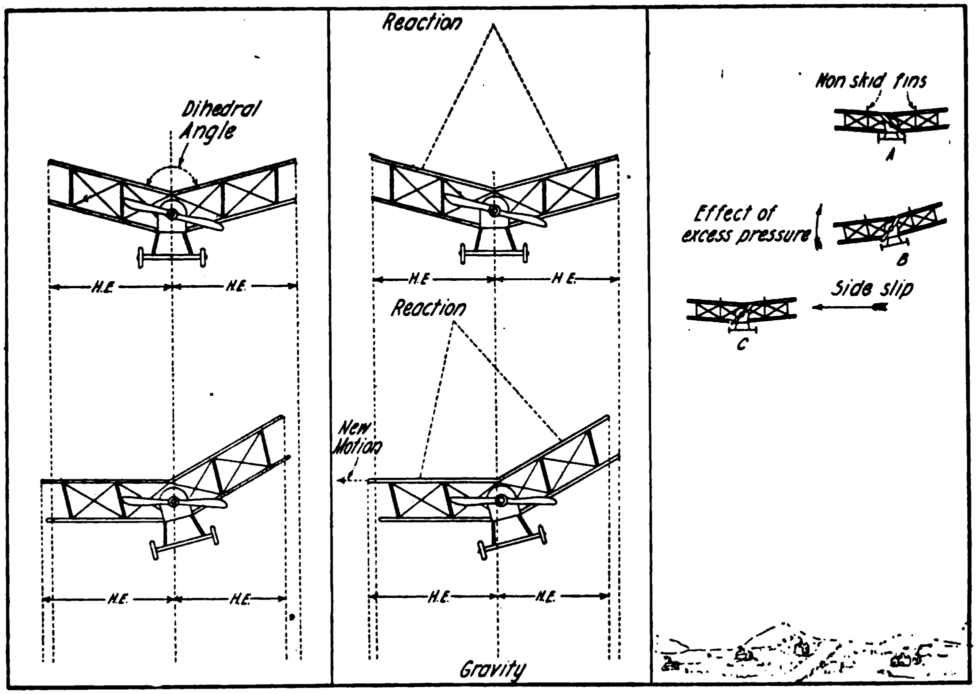


Figure 20 Figure 21 Figure 22

Lateral stabilizing effect of upwardly inclined wings

LATERAL STABILITY

Upward inclination of the lifting surfaces gives a degree of lateral stability, the wings forming a dihedral angle. The tendency to a sideways roll through air disturbance is thus corrected by the lower wing gaining greater pressure or lift and the consequent side slip restoring the machine to level position.

In the upper portion of figure 20 is a representation of a front view of an aeroplane in flight, lifting surfaces having equal horizontal equivalent. When the machine is tilted sideways, as shown in the lower view, the horizontal equivalent (H. E.) of the left wing, now horizontal, has increased; a decrease is seen in the right hand wing, the lower wing in consequence rising through its added lift. The aeroplane is thus restored to its first, or normal, position.

The righting effect is not, however, proportional to the horizontal equivalents of both wings. In the upper portion of figure 21 it is indicated that the reaction, when the aeroplane is at normal position, has a direction opposed to the gravity force, or weight, the two forces being evenly balanced, or equilibrium maintained. In the lower half of figure 21, with the aeroplane tilted sideways the force of reaction is at an angle or not directly opposed to gravity force. The direction of motion is therefore no longer directly forward, the resultant of the thrust and momentum giving the added direction of motion indicated in the drawing. The aeroplane is thus moving sideways while flying forward.

To be effective, the angle of the lateral dihedral must be great enough to force the aeroplane back to equilibrium, and overcome the tendency to turning caused by the increased air pressure exerted on the keel surface, greatest in effect toward the tail.

Figure 22 shows the side slip, with non-skid fins added where excessive dihedral is needed to balance large keel surface.

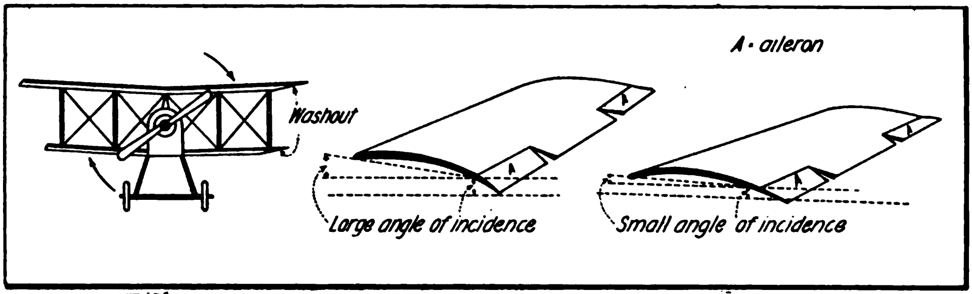


Figure 23—Washout *Figure 24—Ailerons attached to lifting surfaces*

WASHOUT

An aeroplane tends to turn over sideways in a direction opposite to that in which the propeller revolves. The adverse effect of propeller torque (drift) is neutralized by giving the wing tip on the side not affected a smaller angle of incidence.

The washout is shown in figure 23.

Where practicable, the angle of incidence is the also *increased* on the side tending to fall, its lift thereby being increased. Washin is the term used to describe the increased angle.

Washing out the angle of incidence on both sides increases the drift, making possible lessened angle for the ailerons (the lateral controlling surfaces shown in figure 24) which gives them better lift-drift ratio.

AILERONS

In figure 24, the drawing to the right, the smaller angle of incidence of the aerofoil (lifting surface) is given by washout. In comparing it with the other aerofoil (top center of page) it is noted that the ailerons attached to both have the same inclination, although the ailerons of the aerofoil with washout have considerably less angle of incidence, therefore greater efficiency.

BANKING

When an aeroplane is turned off its course it does not instantly proceed along its new course. This is due to the momentum of the original course. The new direction is therefore the resultant of this momentum and the thrust, and the sideways skid caused by the centrifugal force turns the lifting surfaces away from their proper horizontal position, causing lessened lift. Neutralization of this effect is created by "banking," or tilting the aeroplane sideways.

With the angle of the lifting surface changed by banking, the inclination of bottom of the lifting surface makes the pressure or lift force a horizontal component of the centrifugal force. The velocity of the skid is that required to secure an air pressure or lift opposite and equal to the centrifugal force of the turn. The steepness of the bank is governed by the sharpness of the turn, increasing as the strength of the centrifugal force.

It is obvious that when banking the entire lift force is no longer vertical, and it is important that it be sufficient to support the weight of the aeroplane, or it will fall. Speed is a requirement to offset this.

Pilots must not try to climb while banking.

Slight banking results in skidding, which is easily corrected.

Too steep banking, however, may result in a side slip inward, which is likely to be followed by a nose dive.

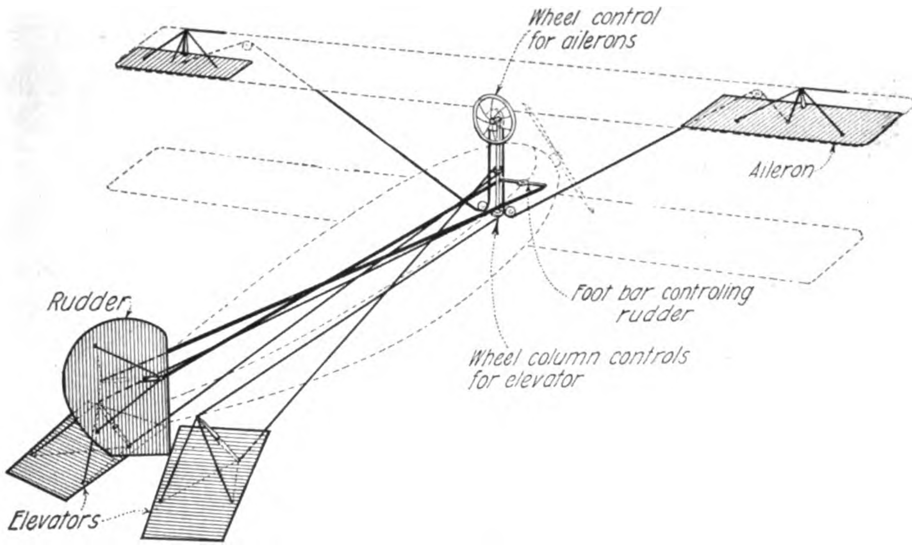


Figure 25—Mechanical means of directional and lateral control

CONTROLS

The illustration above shows the aeroplane's mechanical means of directional and lateral control. These comprise operation of the elevators, ailerons (sometimes called "wing flaps," when attached to main lifting surfaces as shown in drawing), and the rudder.

All operate on the principle of air force derived from an inclined plane.

The elevators are controlled, in U. S. training machines, from the column which supports the wheel, as shown.

The ailerons, or wing flaps, for lateral control are moved by the wheel in the cockpit.

The rudder is controlled by a foot bar.

The elevators are inclined up or down to depress or lift the tail of the aeroplane.

The ailerons supply the difference in angle to the two tips of the wings, as needed, causing one to lift more than the other.

The rudder's action in turning the machine is due to the varying wind pressure exerted on the sides when moved to one side or the other.

MILITARY AIRMEN

MAJOR WALTER GLENN KILNER, U. S. A.

Skill and Daring the Predominant Characteristics of the Officer in Charge of the Government Aviation School at Mineola, Long Island

FEW of our Army aviators have seen such varied and spectacular service as Major Kilner. It is not generally realized that American airmen saw actual war service and distinguished themselves in it before any of the flyers in the European air fleets.

The first baptism of fire occurred during the Vera Cruz expedition. Later, in 1916, our airmen played a prominent part with General Pershing's punitive expedition. Major, then Lieutenant, Kilner first came into prominence while making daring flights over Mexican territory. When our troops were mobilized for the invasion eight tractor biplanes were shipped to the border and the unprecedented difficulties of the American flyers began. Major Kilner and his associates had never before faced such conditions. The water in the radiators of the aeroplanes stood at 120 degrees, and the propellors flew to pieces in the rarified air.

The deserts were covered with soft sand or small bushes which proved extremely dangerous to aeroplanes in rising or landing. Once aloft the flyers encountered perplexing air currents, even whirlwinds, which caught and overturned their machines. The aeroplane division, nevertheless, soon proved its usefulness. Lieut. Kilner and his associates quickly overcame this baffling situation and established regular communication with General Pershing's rapidly advancing column and its base. It required four days to carry dispatches by truck from the base to the head of the column, until the army aeroplanes established a regular mail service, covering the distance of 120 miles in sixty-six minutes. In March, 1916, Major Kilner and another Army aviator were reported lost in Mexico and the country anxiously awaited further news. He returned in safety to the United States soil, however, having been brought down during a flight by motor trouble.

Major Kilner attracted the attention of the entire country in the fall of 1916 when he acted as commanding officer of the first aeroplane squadron in America to go aloft on a pleasure cruise. The fleet, popularly known as the "football special," flew from New York to Princeton, N. J., where the flyers attended a football game, and returned without mishap. All of the machines arrived safely in time for the game.

Major Kilner was placed in charge of the Government aviation school at Mineola, Long Island, in September, 1916, where he has since served. He is generally recognized as one of the most skillful and daring aviators in the country. In September, 1916, he was married to Miss Grace Covel in New York City.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE VIII

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE.—This is the eighth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

ELECTROSTATIC CAPACITY AND RADIO FREQUENCY CIRCUITS

THE CONDENSER

(1) Up to this point, we have explained how alternating current can be obtained from a direct current source of supply through the medium of a motor-generator, and furthermore, we have shown how by means of a step-up transformer, a low voltage current can be raised to one of high voltage.

(2) The apparatus next in importance is the **high voltage condenser** which, when charged and discharged through what is known as a **closed oscillation circuit**, generates the extremely high frequency currents which are employed for the production of the electric waves of wireless telegraphy.

(3) The condenser possesses **electrostatic capacity**, i. e., the ability to store up energy in the form of electrostatic lines of force.

(4) The electrostatic capacity of a condenser or conductor is measured by the quantity of electricity in coulombs with which it must be charged to raise its potential to one volt.

(5) The **capacity** of a **condenser** is expressed by the unit termed the **farad**. A condenser has capacity of one farad when an E. M. F. of one volt will store up in it a charge of one coulomb.

(6) A condenser of one farad capacity would be too large for practical use. Hence, to make this unit applicable to every-day practice, the term **microfarad** is employed.

$$\text{One microfarad} = \frac{1}{1{,}000{,}000} \text{ of a farad.}$$

It should be kept in mind, however, that the farad is a unit of such proportions as to compare with the volt and the ampere.

(7) A **condenser**, in practice, consists of two or more conducting plates separated by air or one of the well-known insulating substances, such as paraffine, hard rubber, ebony, or glass.

The insulating medium is termed the **di-electric**.

(8) If the coatings of a condenser be connected to a source of high voltage current such as that furnished by the secondary winding of a step-up voltage alternating current transformer, a powerful electrostatic field will be set up between its plates. And if afterward the plates are connected together by a stout copper wire with a spark discharge gap in series, a powerful spark will discharge between the terminals of the gap.

(9) A distinction must be made between condensers used with high impressed voltages, and those employed in circuits of the order of a few hundred volts. The **di-electric** of **high voltage condensers** is generally a glass plate, a sheet of micanite or ebony.

(10) The **di-electric of condensers for low voltage** circuits is generally paraffine paper, or thin sheets of micanite.

(11) The capacity of a condenser can be expressed in several ways. The following formula will perhaps be the most practical:

$$C = \frac{K \times A \times 2248}{T \times 10^{10}}$$

where C=capacity of the condenser in microfarads
A=the area of the conducting material of one set of plates
T=the amount of separation between plates
K=a certain constant termed the **di-electric constant** which varies with the texture or material of the di-electric.

(12) We see from this formula that the capacity of a condenser will increase as the distance between plates is decreased or, with a given separation, as the surfaces of the plates are made larger. The capacity also varies with the **di-electric**, the higher capacities, for instance, being obtained when glass is employed as the insulating medium.

(13) Comparisons made with different di-electric mediums indicate that the charge accumulated in the condenser is much greater when certain of the well-known insulating materials, such as glass, micanite, etc., are placed between its plates.

For example, if a sheet of glass is inserted between the plates of a condenser of given dimensions, it can store up nine times as much energy as with air at atmospheric pressure; with micanite, six times; with paraffine paper, two, etc.

These quantities are known as the **inductivities** of the di-electric or, more commonly, the **specific inductive capacity.**

(14) We may define **inductivity** as the ratio of the capacity of a condenser, when its plates are separated by an insulating substance, to that when they are separated by air.

(For table of Di-electric Constants, see author's "Practical Wireless Telegraphy.")

(15) Condensers may be connected in series or in parallel. **Several jars connected in parallel** act as a single jar of increased dimensions.

Jars in series act as a single condenser of small capacity. Parallel and series connections are shown in Figures 69 and 72, respectively.

OSCILLATION GENERATORS

(1) In order to understand the necessity for the foregoing apparatus, i. e., **the motor-generator, the step-up voltage transformer and the condenser,** in a radio telegraph set, we must keep in mind that the **electric waves** of wireless telegraphy are set into motion by currents of extremely high frequency. These currents should oscillate at frequencies in excess of 10,000 cycles per second, and viewed from the standpoint of wireless practice aboard vessels, frequencies from 500,000 to 1,000,000 cycles per second are most desirable.

Currents of extremely high frequency are generated by discharging the energy stored up in a condenser through what is termed a **radio frequency circuit.**

(2) **A radio frequency circuit** may be either an **open** or **closed oscillation circuit.**

An **open circuit** of radio frequency dimensions, if set into excitation, will radiate **electrical waves** which travel through space at the rate of 186,000 miles or 300,000,000 meters per second.

A **closed circuit** set into excitation will **generate currents of extremely high frequency,** but there will be practically no radiation therefrom.

(3) A closed oscillation circuit of radio frequency dimensions generally consists of a **battery of high voltage condensers,** a **coil** consisting of a few turns of wire, and a **spark discharge gap.** The condenser is charged by a high voltage alternating current at pressures varying from **6,000 to 20,000 volts.** The frequency of the charging current may vary from **60 to 500 cycles per second.**

(4) An open oscillation circuit of radio frequency dimensions generally consists of a **vertical wire** (or a number of elevated wires) extended into space, thoroughly insulated from its supports and connected to earth at one end. Direct connection with the earth is not necessary—what is known as an **artificial earth** or **counter-poise,** which consists of a few wires placed underneath the vertical wire and insulated from the earth, may be employed. Counter-poises are frequently laid on the surface without regard to insulation.

(5) An open circuit may be set into oscillation by placing a **spark gap in series,** the terminals of the gap being connected to a high voltage current, such as that generated in the secondary winding of an induction coil or high voltage alternating current transformer; or, the open circuit may be **inductively coupled to a closed oscillation circuit,** the oscillations generated in the latter being transferred to the former by electromagnetic induction.

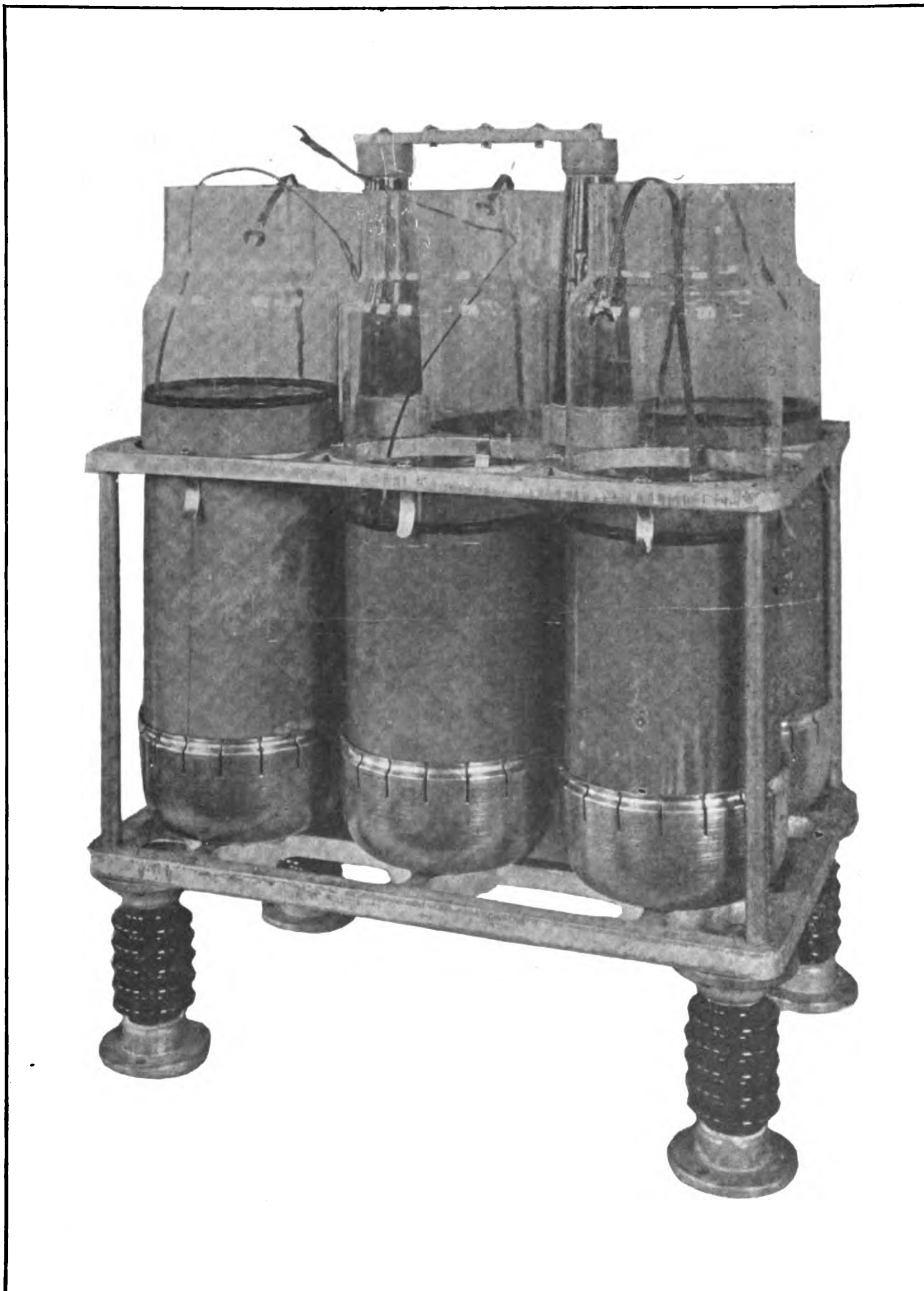


Figure 68.—A battery of copper plated Leyden jars. This unit consists of six jars of .002 microfarad capacity each, making a total value of .012 microfarad, the correct value for a 2 K.W. 500 cycle transmitter. By a special process the inside and outside of the glass are coated with copper, making a very serviceable conducting material which will last for an indefinite period. This is a distinct improvement over the tin foil coated jar which, on account of blistering of the foil, became inoperative after about six months' use. A stranded copper conductor is connected to the inside of the jars and connection is made to the outside through the cups at the bottom. The entire rack is insulated by four electrose insulators

(6) An oscillation circuit whether of the open or closed type possesses three qualities, namely, **inductance, capacity,** and **resistance,** and it is upon these three qualities, measured quantitatively, that the frequency of oscillation depends.

(7) The **frequency of an oscillation circuit** can be computed as follows:

$$N = \frac{1}{2\Pi\sqrt{L, C}}$$

where L=the inductance of the circuit in henries.
" C=capacity in farads.
(This formula ignores the resistance R.)

Since the henry and the farad are too large for practical work, the **centimeter and** the **microfarad** are extensively employed.

1,000,000,000 centimeters=1 henry
1,000 centimeters=1 microhenry

Then, if L be expressed in centimeters and C in microfarads, the **formula for the** frequency of an oscillation circuit becomes:

$$N = \frac{5,033,000}{\sqrt{L, C}}$$

An example of this formula appears in connection with Figure 73.

Generally, in radio frequency transmitting circuits we deal with capacities and inductances of a low order.

(8) We have employed the term **radio frequency** in several instances. This term has been adopted to distinguish the currents employed in radio telegraph work from those of a lower frequency corresponding to audible vibrations.

Currents at frequencies in excess of 10,000 cycles per second are termed currents of **radio frequency.** Those of a frequency less than 10,000 cycles per second are termed currents of **audio frequency.**

This distinction is made in recognition of the limits of the human ear in responding to vibrations in excess of 20,000 per second. Vibrations in excess of this number are generally above the limits of audibility. Since a current of 10,000 cycles per second (if, for instance, it actuated a telephone diaphragm) would correspond to a frequency of 20,000 vibrations per second, the figure 10,000 is employed as the dividing line between a current which would correspond to an audible vibration and one of a higher frequency which, under the conditions outlined above, is inaudible.

(9) Electrical circuits of audio frequency dimensions, in general, have condensers of rather large capacity or coils of high values of inductance, which may possess iron cores. These circuits form a complete contrast to those of radio frequency dimensions which have coils of a few turns minus an iron core or condensers of the order of, say, .001 to .1 microfarad capacity.

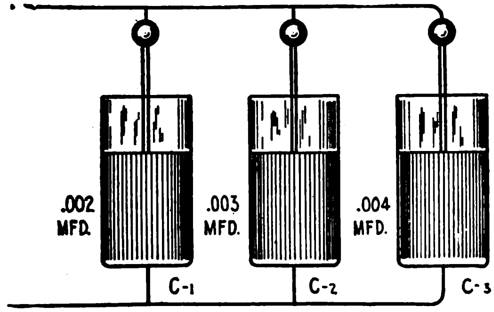


Figure 69.—Showing a battery of Leyden jars connected in parallel. With this connection, the battery acts like a single Leyden jar of enlarged dimensions. To find the capacity of a condenser battery connected in this way, add their individual values. Thus the battery in this figure has capacity of .002+.003+.004 or .009 microfarad.

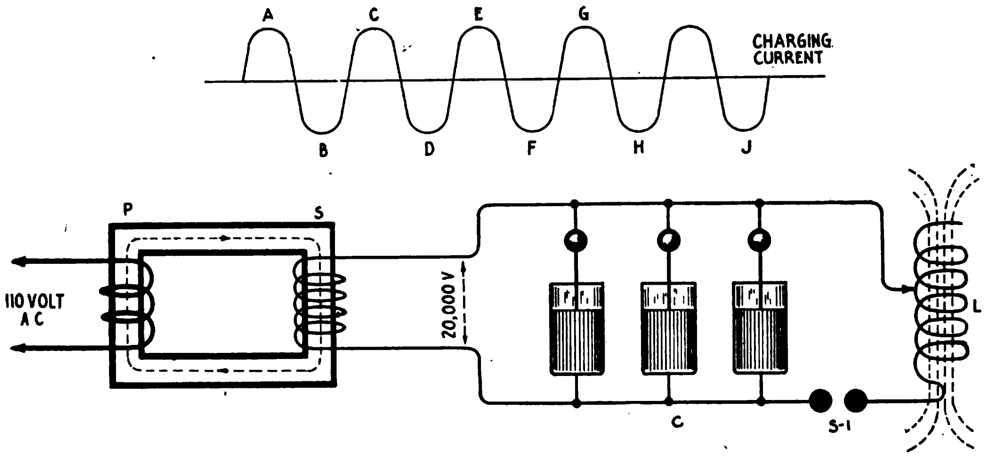


Figure 70

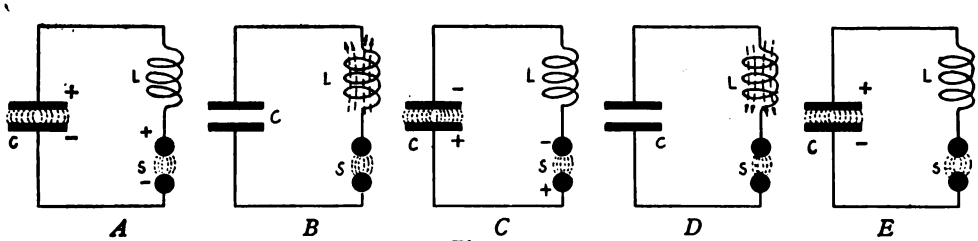


Figure 71

OBJECT OF THE DIAGRAMS

(1) Figure 70. To show the circuits of the apparatus for the production of radio frequency currents.

(2) Figure 71. To indicate the process of the discharge of a condenser.

PRINCIPLE

The energy furnished by the secondary winding of a high voltage transformer may be temporarily stored in a battery of condensers and thereafter discharged through a coil of wire across a spark gap in the form of radio frequency currents.

DESCRIPTION OF THE DRAWING

A closed core high voltage transformer (Figure 70) has the primary winding, P, and the secondary winding, S, current being taken in at the primary at 110 volts and delivered at the secondary at 20,000 volts. Shunted across the secondary winding of the transformer is a battery of condensers, C, the discharge circuit of the condensers comprising the coil, L, and the spark gap, S-1.

OPERATION

If alternating current is supplied to the primary winding, and the spark gap, S-1, is properly adjusted, a violent spark following each alternation of the current will discharge across the gap. The actual number of spark discharges will depend upon the length of the gap, the material of the electrodes, and the voltage of the charging source. For instance, if the spark gap is of such length that it will break down at 10,000 volts, and the potential of the transformer is 20,000 volts or more, two or three spark discharges may take place for each alternation of the current.

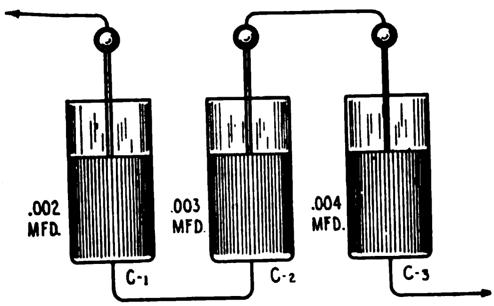


Figure 72.—Indicating a battery of Leyden jars connected in series. If the capacity of each jar has the same value, the resultant capacity will be that of one jar divided by the number of jars in the circuit, but if the jars have unequal capacities, then the following formula applies:

$$C = \frac{1}{\frac{1}{C\text{-}1} + \frac{1}{C\text{-}2} + \frac{1}{C\text{-}3}}$$

Hence the jars of Figure 64 have capacity of

$$\frac{1}{\frac{1}{.002} + \frac{1}{.003} + \frac{1}{.004}}$$

The advantage of this connection, particularly in radio transmitters, is that the voltage from a given source can be distributed among the three condensers, thereby reducing the strain on the dielectric of the individual jar, but since the capacity of the entire unit is thereby reduced, a greater number of jars will be required for the series connection than for a parallel connection of the same capacity. If the terminals of this battery of jars are connected to a 20,000 volt transformer, the voltage, if each jar possessed identical values of capacity, would be equally distributed, i. e., 6,666 volts across each jar.

A distinction should here be drawn between the radio frequency oscillations which discharge through the condenser circuit and the audio frequency current furnished by the charging source. The discharge at the spark gap, S-1, will take place at audio frequent rates, but the frequency of the oscillations composing the individual spark discharges depends upon the self-inductance and capacity of the circuit, L, C, S-1.

The complete cycle of events in the discharge of a condenser is shown in Figure 71. If the condenser C (Figure 71a) is connected to a high voltage transformer and at any particular instant the polarity of the charging source is (+) and (—) as indicated, then the energy at the beginning is all **electrostatic** in the condenser, C. The strain at the spark gap, S, is such that the surrounding air becomes ionized and a spark discharge takes place, whereupon the energy which was formerly electrostatic between the plates of the condenser now becomes **electromagnetic,** surrounding the coil, L, and leads connecting to the condenser (71b).

The collapse of the field around the coil, L, creates the condition of Figure 71c where the counter E. M. F. set up thereby charges the condenser, C, to the opposite polarity, but a charge less in quantity will be stored up at this instant than that originally supplied in Figure 71a.

The condenser discharges across the gap again, as shown in Figure 71d, and its energy once more is converted into a magnetic field about the coil, L. The collapse of the magnetic field charges the condenser to the polarity shown in Figure 71a, but the total amount of energy stored up between the plates of C will be less than at the beginning.

It is thus seen that when an isolated charge of electricity is supplied to the condenser plates, the charges do not completely neutralize at the first instant of discharge, but, in fact, several alternations of current take place at an extremely rapid rate before equilibrium is restored.

This gradual extraction of energy from the oscillations is termed the **damping of the oscillations** and the decrease in amplitude of successive cycles can be expressed in logarithmic percentage.

SPECIAL REMARKS

(1) The circuit, L, C, S-1, in radio telegraphy is called the closed oscillation circuit. This apparatus generates the radio frequent currents of wireless telegraphy.

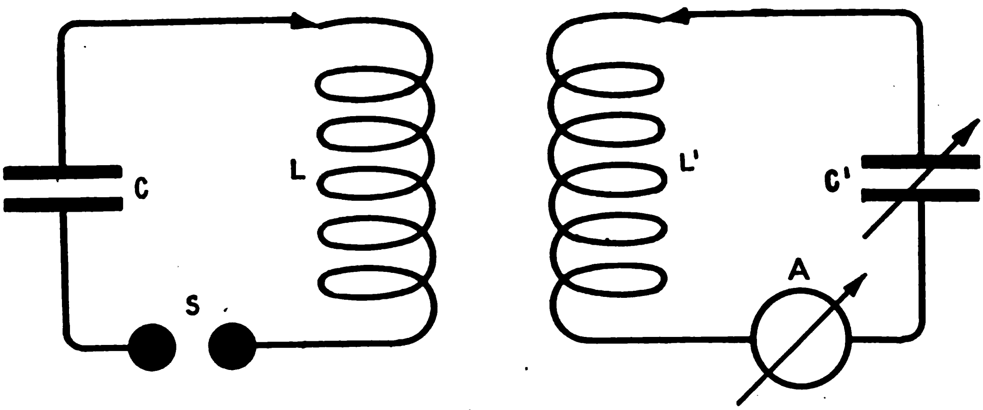


Figure 73

OBJECT OF THE DIAGRAM

To illustrate the circuits of the apparatus for demonstrating the principles of electrical resonance.

PRINCIPLE

In order to transfer energy most effectively from one radio frequency oscillation circuit to another, the product of the inductance multiplied by the capacity in each circuit must be equal, i. e., the two circuits must possess substantially the same natural frequency of oscillation.

DESCRIPTION OF THE DRAWING

Circuit L, C, S, is the generating circuit; circuit L-1, C-1, A, the absorbing circuit which is to be placed in resonance with the circuit L,C, S.

C is a high voltage condenser, charged by a step-up voltage transformer; L, a radio frequency inductance comprising a few turns of stout copper wire or tubing; and S a spark gap.

L-1 is a variable inductance, C-1 a variable condenser, and A a hot wire ammeter.

OPERATION

The two circuits may be placed into electrical resonance as follows:

Set L, C, S, into excitation by connecting C to the secondary terminals of a high voltage transformer. Place L-1 in inductive relation to L, and follow this by changing the value of L-1 or C-1 until the hot wire ammeter A indicates a maximum deflection.

If the resistance of the two circuits is not excessive, the resonant adjustment of circuit L-1, C-1, A, will be sharply defined, that is, a very slight change of inductance or capacity will cause a large decrease in the reading of the ammeter.

SPECIAL REMARKS

(1) If the upper end of the coil, L-1, is connected to an aerial wire and the lower end to earth, the oscillations generated in L, C, S will act inductively on L-1, and if resonance is established, powerful currents will flow in the aerial circuit. **Electrical radiation** will then take place.

(2) The process of establishing resonance between the two circuits can be reversed. The values of L-1 and C-1 are set and the inductance of L or the capacity of C, varied until a maximum deflection of the ammeter, A, is obtained.

(3) If resonance cannot be established by this experiment, it is an indication that the values of L-1, C-1, and L, C, are incorrect for resonance.

(4) **We may now state the general rule that two oscillation circuits of radio frequency are in electrical resonance when the product of the capacity multiplied by the inductance in one equals the product of the inductance multiplied by the capacity in the other.** It makes substantially no difference whether the two circuits to be placed in resonance are open and closed oscillation circuits, or whether two closed or two open circuits are under consideration.

(5) To illustrate rule (4): If in Figure 73, L=25,000 centimeters; C=.001 microfarad; L-1=5000 centimeters and C-1=.005 microfarad; then L×C=L-1×C-1 for $\sqrt{25{,}000 \times .001} = 5$ and $\sqrt{5{,}000 \times .005} = 5$. The factor 5 is known as the **oscillation constant of this particular circuit.**

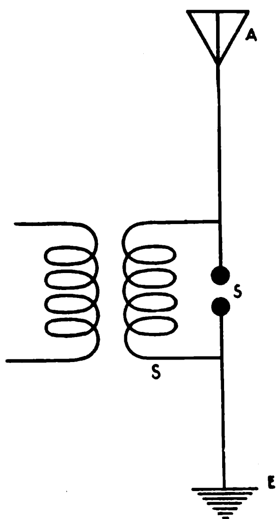


Figure 74

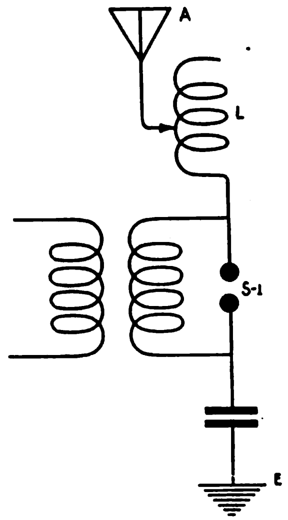


Figure 75

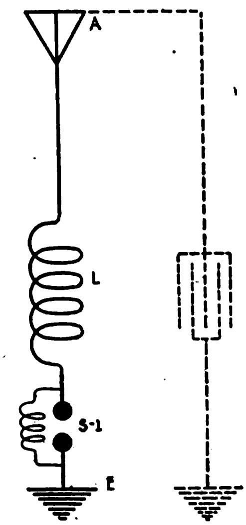


Figure 76

OBJECTS OF THE DIAGRAMS

(1) Figure 74. To indicate the simplest method of setting electric waves into motion.

(2) Figure 75. To show how the length of the radiated wave can be artificially increased or decreased within the wireless telegraph station.

(3) Figure 76. To illustrate how the effective capacity of a wireless telegraph aerial completes the circuit for high frequency currents.

PRINCIPLE

If an insulated, elevated conductor is connected to earth with a spark discharge gap in series, and furthermore, the terminals of this gap are connected to a source of high voltage current, the vertical wire will be charged periodically, a series of sparks will take place across the gap, and radio frequent oscillations will traverse the aerial circuit. Part of the energy of these oscillations will be radiated in the form of a wave motion.

This wave motion will have a distinct length between points of maximum or minimum disturbance, the length of the waves being related to the frequency of the oscillations in the following way:

$$\lambda \quad \frac{V}{N}$$

where V=the velocity of propagation of electrical waves in ether.
where N=the frequency of oscillation.
where λ =the wave length in meters.
(V=186,000 miles per second or 300,000,000 meters per second approximately.)

DESCRIPTION OF THE APPARATUS

In Figure 74, a spark discharge gap, S-1, is connected in series with the wire, A, and is connected in shunt to the secondary winding of high voltage transformer, S.

In Figure 75, a coil of wire, L, and a high voltage condenser, C, are connected in series with the aerial circuit to increase or decrease, respectively, the length of the radiated wave.

Figure 76 illustrates to the student how the electrostatic capacity of the vertical wire serves to complete the circuit between the aerial and the earth, but it should be understood that not only the upper portions of the antenna contribute to its capacity, but all parts from the earth up as well.

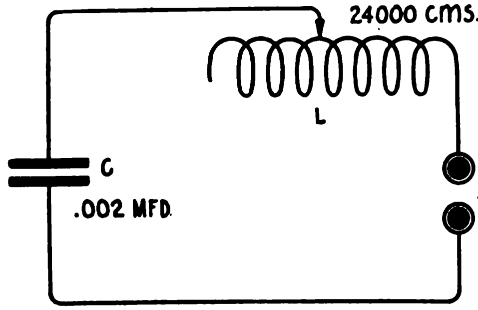
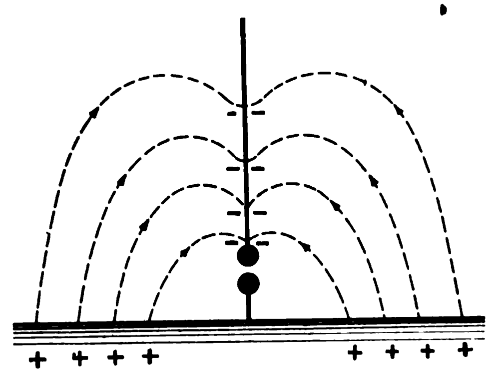


Figure 77.—Diagrammatic sketch of a closed oscillation circuit such as is employed in radio transmitters. If the coil, L, has inductance of 24,000 centimeters and the condenser, C, capacity of .001 microfarad, the frequency of oscillation is equal to

$$\frac{5{,}033{,}000}{\sqrt{24{,}000 \times .001}} = 1{,}027{,}142$$

The quotient of this problem does not imply that one million + cycles of current actually took place in one second of time, but that during the period of oscillation the condenser discharged through the inductance at this rate. To explain more clearly: If the frequency of the current at the charging source is 500 cycles per second, and the spark gap, S, is adjusted for one discharge for each alternation of current, then there will be 1,000 sparks per second and each spark will consist of from three to ten complete cycles before the energy has been dissipated.

Figure 78.—Showing the electrostatic field about a vertical oscillator previous to the discharge of the spark across the gap. When the electric strain about the aerial for a given voltage has reached its maximum value, a spark discharges across the gap and a part of the static field is converted into an electric current and the remainder into a wave motion. The current will oscillate to and fro in the aerial circuit at a radio frequency depending upon the distributed values of L and C, and the oscillations will be damped out at a rate depending upon the radiation characteristic of the aerial and the resistance of the wires and earth connection. The passage of this current to and fro in the aerial system is accompanied also by a magnetic field part of the energy of which contributes to the wave motion



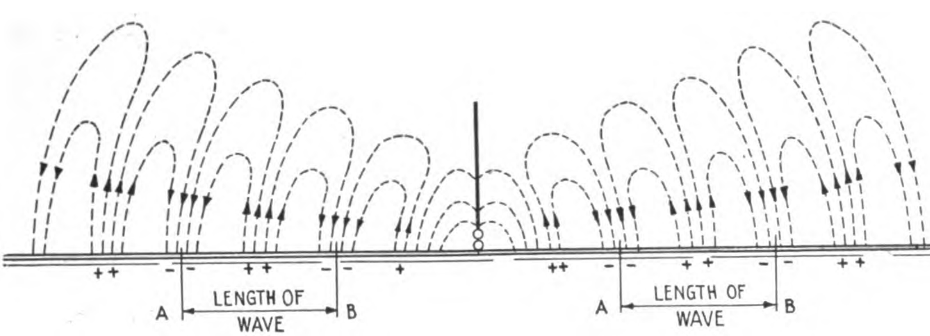


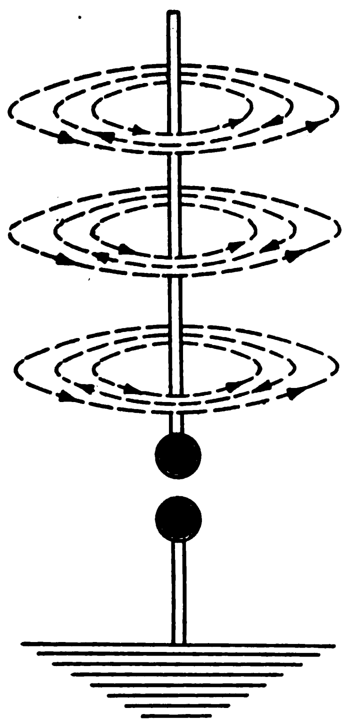
Figure 79.—Showing several groups of detached loops of electrostatic strain about a wireless transmitting aerial. The distance between two points of maximum or two points of minimum disturbance, where the electrostatic field is in the same direction, gives the length of the wave. Thus, the distance from A to B is the length of one wave. The electric waves used in the dispatch of wireless traffic from shore to ship and from ship to shore vary in length from 300 to 600 meters corresponding to 1,000 and 2,000 feet respectively.

If the frequency of the oscillations flowing in an aerial circuit is known, the length of the wave can be determined by dividing the velocity of propagation of electric waves (300,000,000 meters per second) by the frequency.. For example, if the frequency of the antenna current is 500,000 cycles per second, then the length of a single wave in the resultant wave motion will be $\frac{300{,}000{,}000}{500{,}000} = 600$ meters.

OPERATION

If a high voltage transformer is connected to the spark gap S-1 in Figure 74, sparks will discharge across the gap at a rate depending mainly upon the voltage of the transformer, and the length of the spark gap, and each spark discharge will consist of radio frequency currents flowing up and down the vertical conductor. These currents will displace a portion of their electrostatic and electromagnetic energy about the aerial giving a shock to the surrounding ether, and setting into motion the electric waves of wireless telegraphy.

If turns are added at the coil L (Fig. 75) the currents will oscillate through the aerial circuit at a slower rate and the aerial will therefore radiate a wave of increased length, but if a capacity is inserted in series with the aerial as shown by the condenser, C, the current will oscillate at a higher frequency and the aerial will radiate a wave shorter than its natural wave-length.



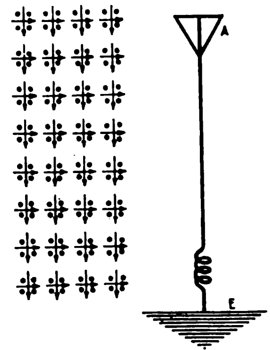


Figure 81.—Showing a partial section of an advancing wave about to cut through the receiving aerial. The horizontal arrows represent the direction of movement; the downward vertical arrows the direction of the static field; and the circles the magnetic lines of force. These two fluxes act simultaneously upon the aerial at the distant receiving station, A, E, inducing therein a current of the same frequency as that flowing in the transmitting aerial. If the circuit, A, E, is placed in electrical resonance with the distant transmitting station, currents will be built up to the maximum amplitude, and by means of proper devices within the receiving station, the presence of these currents can be detected

Figure 80.—Showing the magnetic field around an aerial for three alternations of current; both the static and magnetic fields in the process of radiation, give a shock to the surrounding ether setting up a wave motion which travels at the speed of light, viz., 186,000 miles per second

QUES.—What are the principal radio frequency circuits of a wireless telegraph transmitter?

ANS.—The open and closed oscillation circuits.

QUES.—What is the function of the closed oscillation circuit?

ANS.—To generate radio frequency currents.

QUES.—What does the closed circuit consist of?

ANS.—In spark telegraphy, it consists of a high voltage condenser, a radio frequency inductance, and a spark discharge gap.

QUES.—What is the function of the open oscillation circuit?

ANS.—To radiate a portion of the energy of the high frequency currents in the form of an electromagnetic wave.

QUES.—What does the open oscillation circuit of the transmitter consist of?

ANS.—It consists of one or more insulated, elevated, conductors connected to earth at one end, which may be set into electrical oscillation either by direct excitation or by indirect coupling to a closed oscillation circuit.

The open circuit of a modern wireless telegraph transmitter usually contains, in addition to the aerial wires, an aerial tuning inductance, the secondary winding of an oscillation transformer, a short wave condenser, and an aerial ammeter.

QUES.—What are the functions of the spark discharge gap in the closed oscillation circuit?

ANS.—The functions of the gap are:

(1) to keep the condenser circuit idle until it is fully charged;

(2) to discharge the energy of the condenser in the form of radio frequency currents;

(3) to quench out the oscillations of the closed circuit at the proper time.

QUES.—What is the usual cdpacity of the condenser of a wireless telegraph transmitter?

ANS.—The capacity varies with the power, the frequency and the voltage of the current. For example, the capacity of the condenser of a 1 K.W. 500 cycle transmitter is .006 microfarad; of a 2 K.W. 500 cycle transmitter .012 microfarad. In transmitting sets operated at the commercial wave-lengths of 300 to 600 meters, the capacity of the condenser rarely exceeds .025 microfarad.

QUES.—What voltages are employed to charge the transmitting condenser?

ANS.—In the early stages of the wireless art, voltages from 25,000 to 60,000 were employed, but in transmitters of later design the voltage of the secondary rarely exceeds 15,000 volts, pressures as low as 6,000 volts having been used.

QUES.—Why are 500 cycle alternators employed in wireless transmitting apparatus?

ANS.—The tone of the spark discharge is faithfully reproduced at the receiving station. Since the spark discharge created by a 500 cycle current has a much higher pitch than that of a 60 cycle current, the former is employed. A spark of high pitch enables the receiving operator to discriminate between the signals of a given transmitting station and those due to the crashes of atmospheric electricity.

QUES.—Name the principal parts of a radio transmitter.

ANS.—The principal parts are:

(1) Alternator
(2) Step-up voltage transformer
(3) High voltage condenser
(4) Spark gap
(5) Oscillation transformer
(6) Aerial
(7) Earth connection

Editorial Notes—The transmitter will be treated in detail in the next article of this series.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

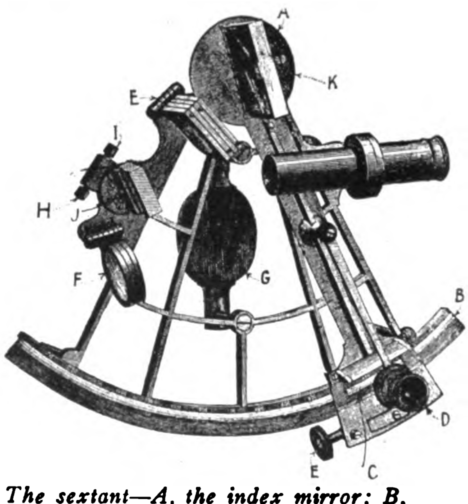
By CAPTAIN FRITZ E. UTTMARK

ARTICLE III

The Ship's Chronometer

The chronometer

THE chronometer is simply a carefully made clock so constructed as to keep reliable time. The aim of the makers is to produce a time-piece that will gain or lose at a small, uniform rate (an absolutely accurate time-piece is not possible), so that the error at all times may be computed. Its chief feature is a variable level which enables the force of the mainspring to act uniformly even when the chronometer is exposed to great variation of temperature, such as would be experienced from extreme cold during a long voy-



The sextant—A, the index mirror; B, the arc; C, the vernier scale; D, the microscope; E, the tangent screw; F, shade glasses; S, handle; H, I, J, adjustment screws for horizon glass; K, adjustment screws for index glass

age in the Arctic to extreme heat when crossing the Equator or at tropical ports. The chronometer as used on board the ship is generally regulated to keep Greenwich time and used in calculating the astronomical longitude of the ship.

The Sextant

The sextant is an instrument of reflection used for measuring altitudes of heavenly bodies and angles in general. Its arc is generally graduated in degrees

and ten-minute divisions, and its vernier in minutes and ten-seconds of arc. It is a sixth part of a circle, or sixty degrees, and according to the law of reflection we can measure angles of double that amount or 120 degrees of arc.

The Octant or Quadrant

This is an instrument belonging in the same class as the sextant and used for the same purpose, but which has a smaller scope when used for measuring angles. It may be defined as an instrument of reflection for measuring altitudes of heavenly bodies, or angles in general. The arc is graduated in degrees and fifteen or twenty-minute divisions and its vernier in minutes and fifteen or twenty-seconds of arc. This instrument will read to at least ninety degrees of arc. It is called an octant because it is an eighth part of a circle, or a quadrant because and according to the law of reflection we can measure angles of double that amount or ninety degrees of arc.

Errors of the Octant or Sextant

These are found and corrected by going through the following four adjustments, namely of the index mirror of the horizon glass and of the telescope.

The first adjustment is to see if the index glass is perpendicular to the plane of the instrument; this is done by moving the sliding limb to the center of the arc; then noting if the arc reflected in the index glass and the arc seen direct form one unbroken line. If they do, the index glass is perpendicular, but if not, make this adjustment with the screw on the back of the index glass.

The second adjustment is to see if the horizon glass is perpendicular to the plane of the instrument; this is done by making the two zeros coincide with one another and then holding the instrument at an angle slightly inclined from the horizontal plane; if the reflected horizon and that seen direct form one unbroken line the horizontal glass is perpendicular, but if not make this adjustment with the top screw on the back of the horizon glass.

The third adjustment is to see if the horizon glass and the index glass are parallel to each other. To do this make the two zeros coincide, then hold the instrument vertically, and if the reflected horizon and that seen direct, form one unbroken line, the glasses are parallel; but if not, make this adjustment with the bottom screws on the back of the horizon glass.

If it is not possible to make the glasses parallel by the bottom screw, then make them parallel by using the tangent screw, and the amount the zero of the sliding limb is moved *on* or *off* the arc will be the index error, subtractive if *on* the arc, but additive if *off* the arc.

The fourth adjustment is to see that the axis of the telescope is parallel to the plane of the instrument. For this adjustment the inverting telescope is screwed in the collar of the instrument, and the telescope is turned until the parallel wires are parallel with the plane of the sextant. Two stars which are at least ninety degrees apart are then selected and an exact contact is made at the wire nearest the plane of the instrument. Next the sextant is moved so as to throw the objects on the other parallel wire, and if the angle remains the same this adjustment is correct, but if it is not perfect the collar adjustment must be made by the screws on the back of the telescope collar. An error in this telescope adjustment always makes angles too great.

CHAPTER III

Definitions of Terms Used in This Series

The Right Angles.—A right angle is an angle of ninety degrees (90°) or the fourth part of a circle. All the angles in Figure 1 are right angles.

The Oblique Angles.—An angle greater or less than 90° is called *oblique.*

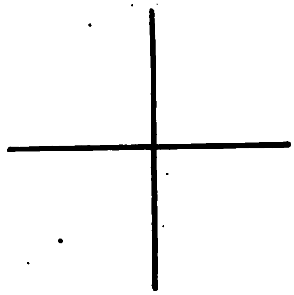


Figure 1

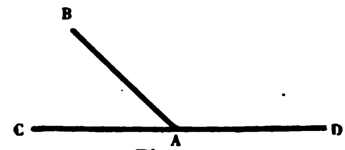


Figure 2

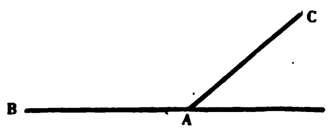


Figure 3

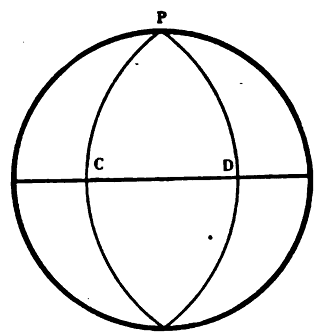


Figure 4

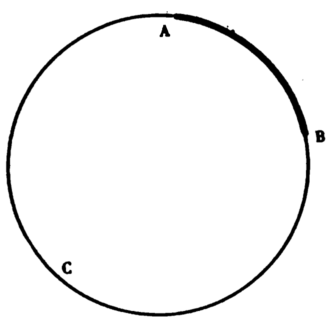


Figure 5

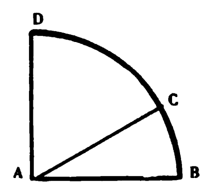


Figure 6

The angle B A C and B A D (Figure 2) are oblique angles.

The Obtuse Angle.—An angle greater than 90° is called *obtuse.*

The angle B A C (Figure 3) is an obtuse angle.

The Spherical Angle.—An angle formed by intersection of two great circles is called a *spherical angle.*

The angle C P D (Figure 4) is a spherical angle.

The Arc.—A part of the circumference of a circle is called an *arc.*

The curved line A B (Figure 5) is an arc of the circle A B C A.

Complement of an Arc or Angle.—The difference between an arc or angle and 90° is called *complement* to that *arc* or *angle.*

The arc, C B, (Figure 6) is the complement to CD. The angle, B A C, is the complement to C A D.

The angle, D A B, is a right angle.

Supplement to an Arc or Angle.—The difference between an *arc* or *angle* and 180° is called its *supplement.*

The arc, C B, (Figure 7) is the supplement to C D.

The angle, C A B, is the supplement to C A D.

The Great Circle.—A circle whose plane passes through the center of a sphere is called a *great circle.* All the lines in Figure 8 are great circles.

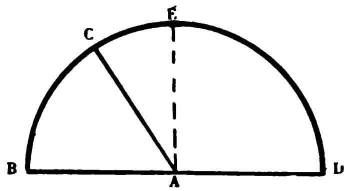


Figure 7

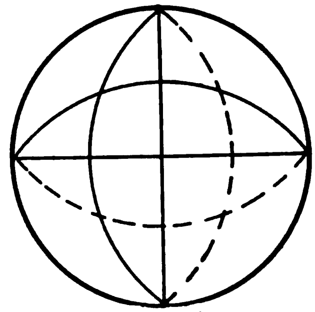


Figure 8

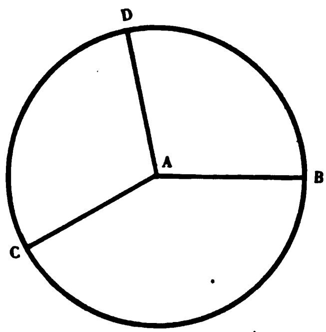


Figure 9

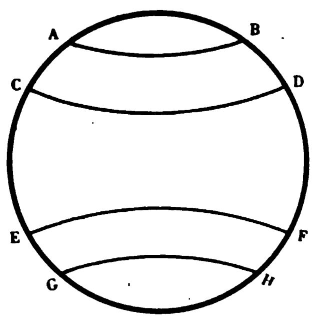


Figure 10

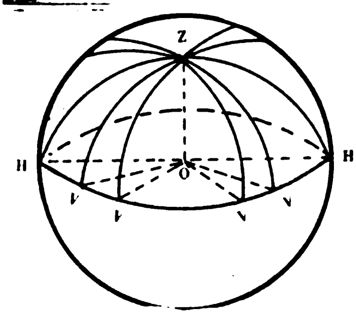


Figure 11

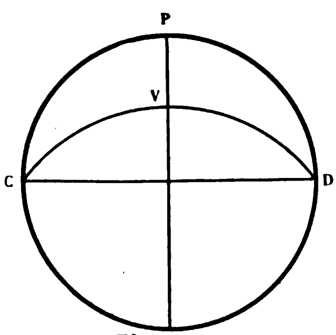


Figure 12

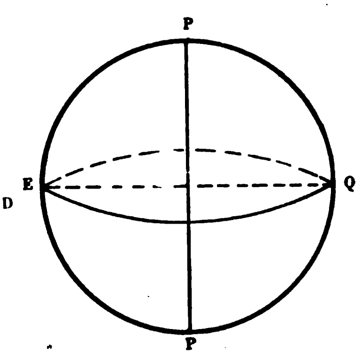


Figure 13

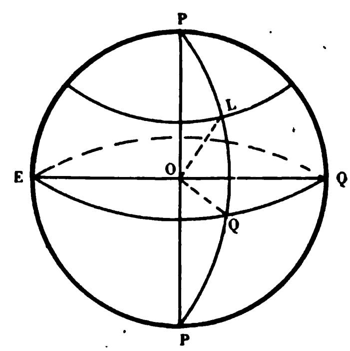


Figure 14

The Radius.—A straight line drawn from the center of a circle to its circumference is called *radius.* The lines, AB, AC and AD are radius to the circle in Figure 9.

Small Circles.—Circles whose planes do not pass through the center of the sphere are called *small circles.* AB, CD, EF and GH are small circles. (Figure 10.)

Zenith and Nadir.—The point vertically overhead of the observer is called *zenith* and the point vertically beneath is called *nadir.*

Vertical Circles.—Great circles passing through zenith perpendicular to the horizon are called *vertical circles or verticals.*

Z is the zenith.

O is the place of the observer.

H H′ is the observer's horizon.

Z V are all vertical circles or verticals. (Figure 11.)

The Vertex of a Great Circle.—The point of a great circle which is nearest the pole is called its *vertex*.

CD is a great circle. P is the pole to the circle. V is the vertex of the circle C D. (Figure 12.)

The Equator.—The equator is a great circle formed by the intersection with the earth's surface of a plane perpendicular to its axis. The equator is equidistant from the poles. Every point of the equator is ninety degrees from the poles. The great circle, E Q, is the equator. (Figure 13.)

Latitude.—The latitude of a place or position on the earth is the arc of the meridian intercepted between the equator and the given place. Latitude is reckoned from the equator (Lat. 0) and expressed in *degrees, minutes* and *seconds* north and south, up to 90° at the poles.

P is the pole.

E Q E is the equator.

L O Q or L Q is the latitude of L. (Figure 14.)

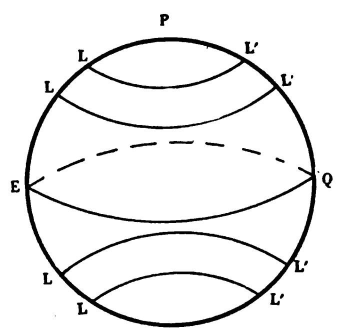


Figure 15

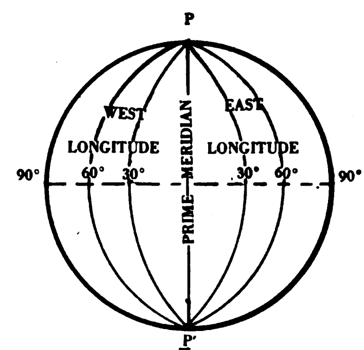


Figure 16

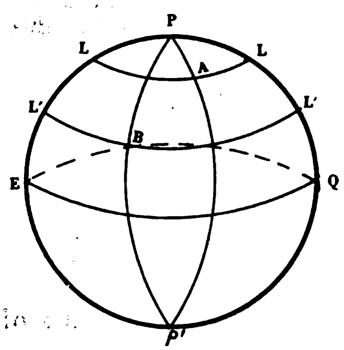


Figure 17

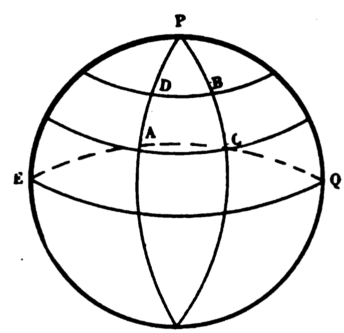


Figure 18

Parallels of Latitude.—Parallels of latitude are small circles formed by intersection of planes parallel to the *equator*.

E Q is the equator.

L L' are parallels of latitude. (Figure 15.)

Longitude.—The angle at the pole contained between the meridians of any place or position on earth and a certain meridian assumed to be the first or prime meridian. The longitude is measured on the equator and reckoned east or west up to 180°. The meridian passing through the observatory at Greenwich, (England), is generally accepted as the first meridian. Figure 16 illustrates east and west longitude.

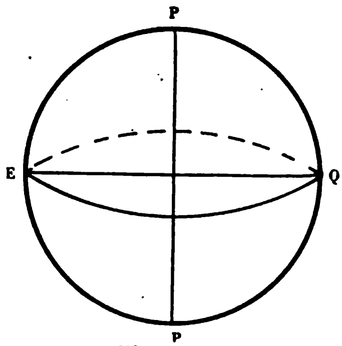


Figure 19

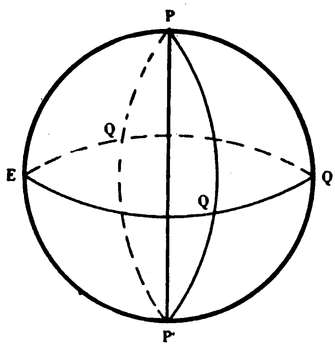


Figure 20

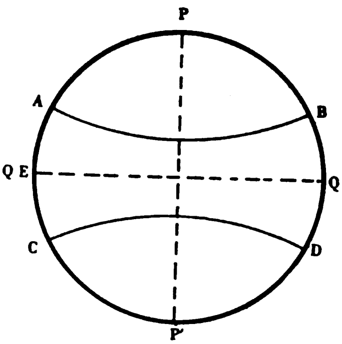


Figure 21

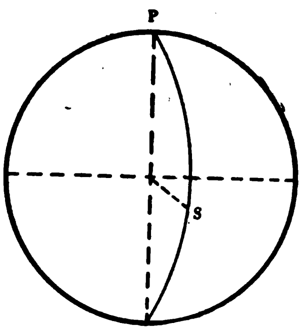


Figure 22

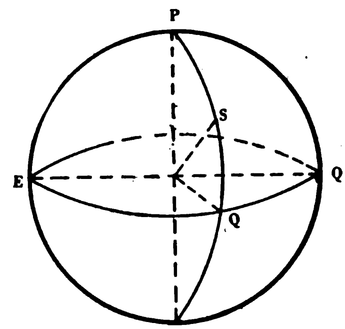


Figure 23

Difference of Latitude.—The *difference* of latitude between the two places, A and B, is the arc of a meridian intercepted between the parallels of latitude of the given places and is named north or south according to the direction from one place to the other.

The difference of latitude between A and B is L L′ reckoned *south* from A or *north* from B. (Figure 17.)

Departure.—The departure is the distance east or west between the meridians of two places or positions and is reckoned in *miles*. We must note that this distance decreases as the meridians converge towards the poles.

The departure between the meridians of A and B is the distance A C in miles on the latitude of A or the distance, D B, in miles on the latitude of B. (Figure 18.)

Terrestrial Poles.—The terrestrial poles are the terminal points of the earth's axis around which the earth revolves.

P represents the north pole.
P′ represents the south pole.
The line, P P′, represents axis of the earth. (Figure 19.)

Meridians.—Meridians are great circles passing through the poles and cutting the equator at right angles.

The great circles, P Q P′ Q, are all meridians.
E Q is the equator. (Figure 20.)

The Tropics.—The tropics are small circles approximately 23½° from the equator and mark the extremities of the sun's declination north and south.

A B in the northern hemisphere is called the *tropic of cancer*. C D in the southern hemisphere is called the *tropic of capricorn*.

Polar Distance.—The polar distance of a celestial body is its distance from

the elevated pole of the observer measured upon the circle of declination passing though the center of the body.

It is 90° plus declination if the *latitude* of the observer and the *declination* of the body is of opposite name, but 90° minus *declination* if of the same name.

P is the elevated pole.

P S is the polar distance of S. (Figure 22.)

Declination.—The declination of a celestial body is the angular distance from the equinoctial, measured upon the declination circle which passes through the center of the body. It is named north or south according to its direction from the equinoctial.

E Q is the equinoctial.

S Q is the declination of S. (Figure 23.)

(*To be continued*)

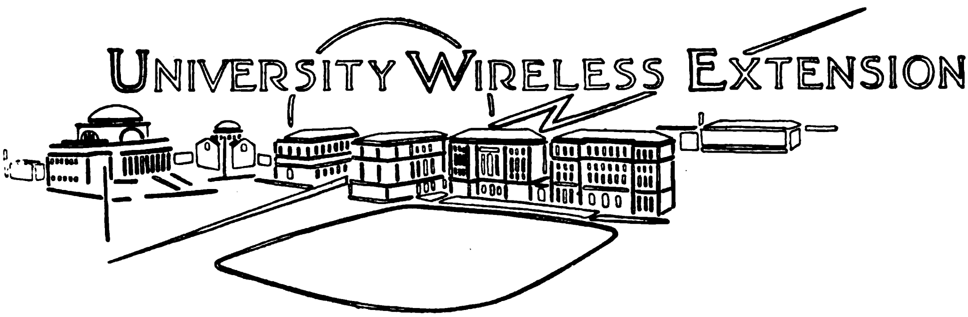
The Outwitting of Germans by a Wireless Operator

A STORY of the wit and resourcefulness of Guy Duncan Smith, an English wireless operator, was brought out recently in the Prize Court, London, when the Government was asked to condemn the steamship Edna because of unneutral service and enemy ownership. The recital hinges upon the activities of a craft which flew two flags and was owned by Frederick Jebson. Sir Frederick E. Smith, the Attorney General, said that Jebson, who was a figure of consequence in the San Francisco shipping world, had used the vessel originally in his Mexican business. When hostilities began in Europe the Edna took aboard gun-sight apparatus and by means of her wireless attempted to inform the German cruiser Leipzig of the time of departure from ports of British vessels. These attempts, however, were defeated by Smith.

One night the wireless operator, listening in, in the radio cabin of the Edna, heard the steamship Aztec flash the news that war had been declared between Russia and Germany. Following this announcement, the name "Hamburg," displayed on the stern of the vessel, was removed, "La Paz" was substituted and the Mexican flag was flown from the mast head.

Smith then found himself in the midst of activities directed against the enemies of Germany. He had learned before the ship left San Francisco that coal taken aboard the vessel was to be transferred to the Leipzig. Those in charge of the Edna began to assume an aggressive attitude toward him. A German operator was taken aboard and Smith was informed that if he failed in his duty the former would displace him. But the German operator was not satisfactory. And Smith saw to it that his work was not made easy. The German attempted to call the Leipzig by wireless, but the English operator had adjusted the apparatus so that it was apparently out of order and the enemy wireless man spent three days and nights trying without success to obtain a response from the Leipzig. Smith, on several occasions, readjusted the set and established communication with the German cruiser, but he made certain always that the other operator's efforts were fruitless.

Threats from the German officers to shoot Smith and throw him overboard if he did not transmit a code message to the Leipzig were without effect, the only message that he sent to the cruiser being an inquiry as to where she was. This brought the response that she was waiting for the Edna. And notwithstanding the close watch the Germans kept on the operator he managed to send a message to the admiral on the American cruiser California. Eventually, however, the Edna was commandeered by the Mexican Government and conditions became more favorable for the English operator.



Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE XII

WE consider next the oscillation radiophone transmitters manufactured by the de Forest Radio Telephone and Telegraph Company. One type of these is illustrated diagramatically in Figure 144, and this arrangement of circuits is due to Mr. C. V. Logwood. It will be seen that the direct current generator *G* (usually of 1,200 to 1,500 volts) is connected in series with the iron

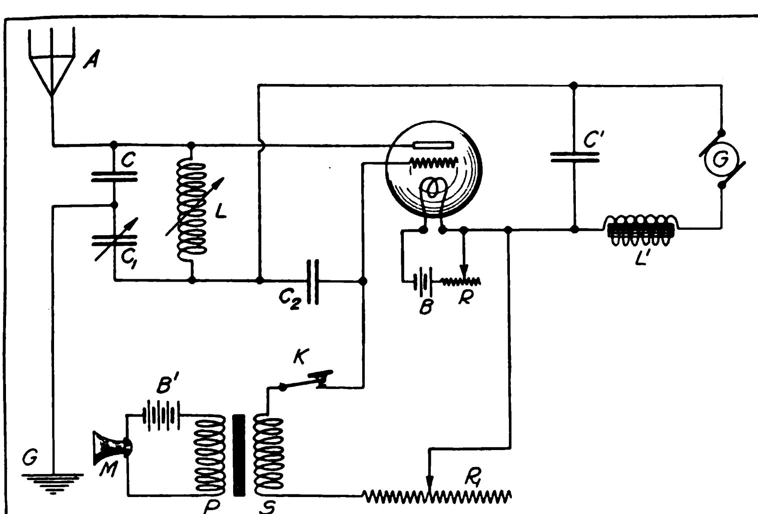


Figure 144—*de Forest Company-Logwood radiophone transmitter*

core choke coil *L'* and shunted by the condenser *C'*, the purpose of these being to cut downthe "commutator ripple" thus giving a more nearly constant e. m. f. in the plate circuit. Failure to observe this precaution leads to a loud and objectionable hum corresponding to the frequency with which the commu-

tator segments pass under the generator brushes. The oscillating circuit used seems to be of the capacitive coupling type or ultraudion type according to the method of classification. It is clear that the antenna capacity is used to absorb the output of the bulb. Modulation is accomplished by impressing audio frequency potential variations, produced by the voice, on the grid. The microphone M causes varying currents in the circuit of the transformer primary P, whence the potential variations are produced by the secondary S in the filament-to-grid circuit. The resistance R_1 in series with S serves to keep the grid strongly negative because of the difficulty experienced by any negative charges on the grid in leaking off to the filament. By varying R_1, the grid potential can be varied. For telegraphy, the key K is used. It merely opens the grid leak circuit, whereupon the grid immediately becomes so negative as to choke off all plate current and thus stop the oscillations entirely. Closing the key permits the excess negative charge to leak off the grid and the oscillations start again.

There is a marked tendency to increase the dimensions and available output of the tubes employed, and this is well illustrated in Figure 145. The left hand tube is of approximately the dimensions of the usual amplifier or "repeater" bulbs used by the Western Electric Company in trans-continental wire telephony. This company is operating under exclusive patent licenses granted by the de Forest Company. The right hand bulb is one of the latest 0.25 kilowatt input oscillions. A 3 or 4 inch (7.5 or 10 cm.) "laboratory oscillion" is shown mounted on its panel in Figure 146. Such a device can produce conveniently a number of watts of radio frequency energy of constant amplitude.

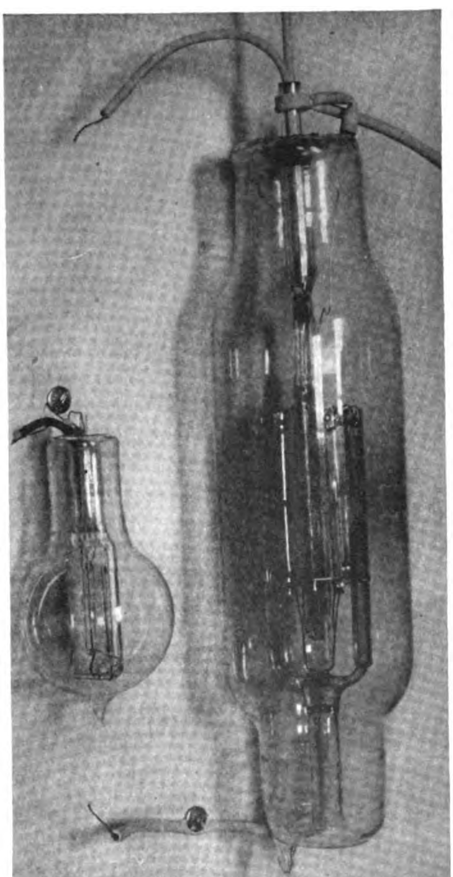


Figure 145—de Forest 0.25 K. W. Oscillion (as compared with type of bulb used in long distance wire telephony)

A whole series of radiophone transmitters have been put on the market by the de Forest Company some of which are here illustrated. A low power set using what is practically one of the tubular receiving bulbs is seen in Figure 147. A larger type of transmitter and receiver, together with the requisite motor generator set appears in Figure 148. This set is stated to have a telegraphic range over water of 40 miles (64 km.) using masts 200 feet (60 m.) high and an antenna span of at least 250 feet (80 m.). The generator of the motor generator set in this case is for 1,000 volts and 100 watts output. A more recent set of this type is shown in Figure 149. The small ammeter at the top left indicates the filament current of the bulb, which requires somewhat careful setting for full output. The right hand top instrument is the antenna ammeter. A convenient form of protected change-over switch from sending to receiving is mounted on the back of the panel, the handle pro-

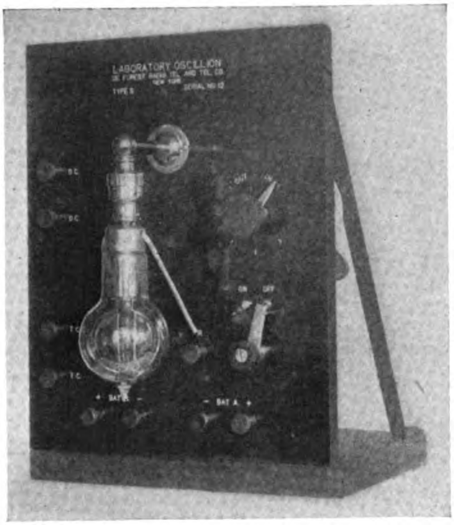


Figure 146—de Forest laboratory oscillion transmitter

Figure 147—de Forest low power radiophone transmitter (Type PJ)

jecting just to the right of the microphone arm. The bulb is also mounted back of the panel, and can be partly viewed through a slit under the microphone arm. The variable condenser to the left of the arm is condenser C_1 of Figure 144. A filament rheostat and binding posts for the filament battery, antenna and ground connections, etc., complete the installation except for a short-circuiting bar between two binding posts. This latter may be removed and replaced by the Morse key, then permitting telegraphy.

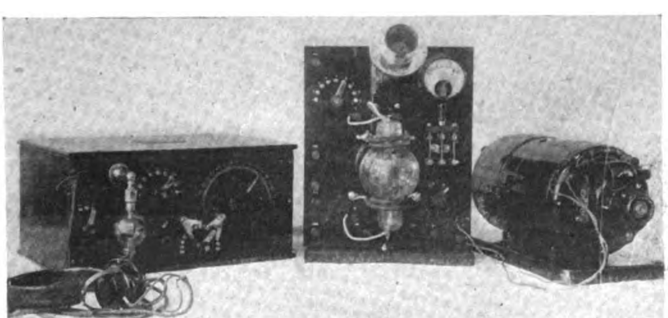


Figure 148—de Forest Oscillion radiophone and radio telegraph transmitter and receiver (Type OJ3)

An extremely interesting aeroplane radiophone transmitter is shown complete in Figure 150. The generator is driven by the air propeller with suitable speed control devices, and is enclosed in the "stream line" casing, the terminal leads being brought out of the rear end. The oscillion is mounted in a protective wire mesh casing and is suspended in such fashion as to be reasonably safe from breakage. The three top instruments are for antenna current, plate circuit current, and filament current. The Morse key is shown at the bottom of the figure together with the microphone. The latter is so arranged as to fit closely to the lips of the user and thus avoid picking up the extremely loud noise of the engine exhaust.

A more elaborate type of radiophone transmitter using three oscillion bulbs is shown in Fgure 151. It includes a "modulator" or master oscillator bulb and two "radio" or amplifier bulbs. These are mounted back of the

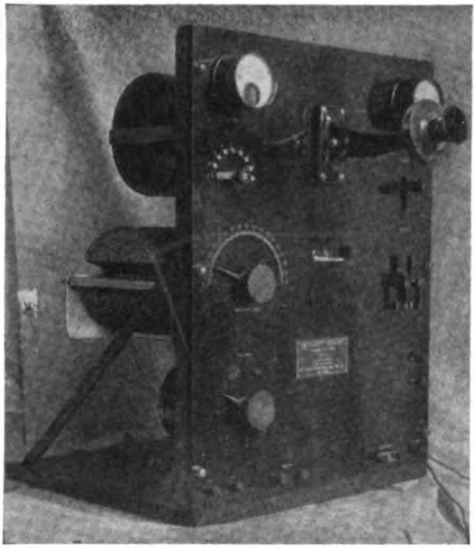


Figure 149—*deForest* 0.25 *K. W. Oscillion radiophone transmitter*

panel, and can be viewed through the three slits. The four instruments at the top of the board (starting at the left) are respectively the "modulator" current, plate circuit current, filament circuit current, and antenna current. The inductance and variable condenser of the master oscillator circuit are mounted directly below the corresponding ammeter at the left. An antenna loading inductance and a control switch for changing from receiving to transmitting are mounted to the right of the microphone transmitter. Under the slit of each bulb and at the bottom of the board are its filament and plate circuit switches and at the bottom of the board are the three filament rheostats. As before, two binding posts are provided at the bottom of the board for the insertion of a Morse key if radio telegraphy is desired. A set of this type is supplied with 1,500 volts for the plate circuit and an input of about 1.5 kilowatt. The telephone range over water is stated to be 400 miles (640 km.) and the corresponding telegraphic range 600 miles (1,000 km.). As

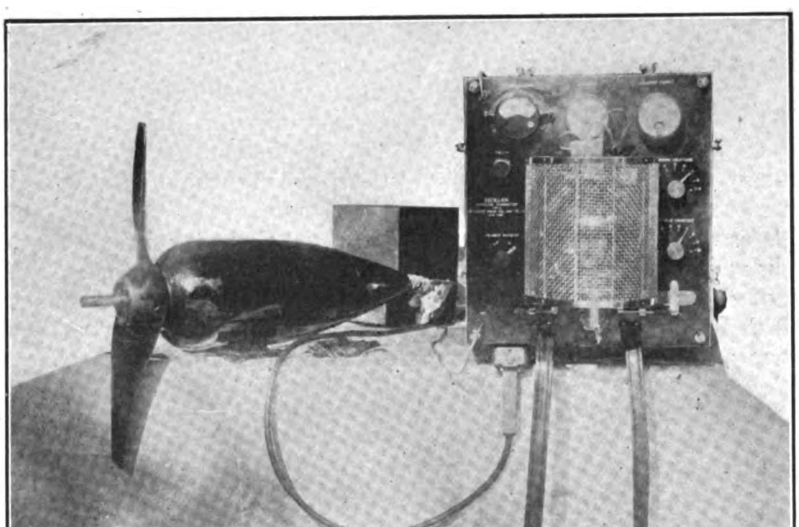


Figure 150—*de Forest* 0.25 *K. W. Oscillion radiophone and radio telegraph transmitter*

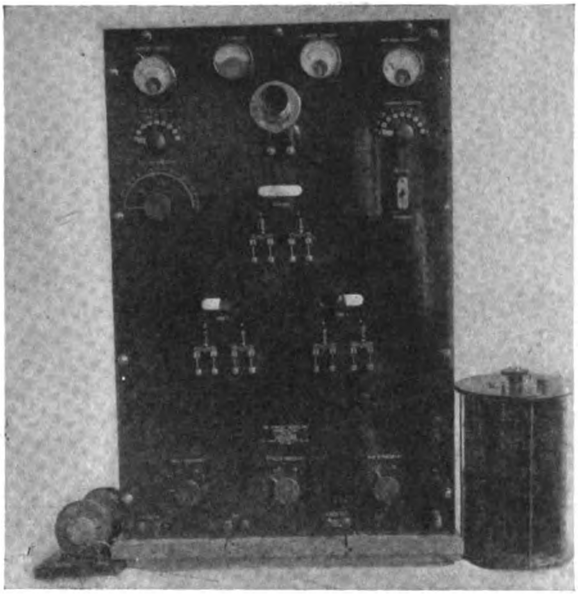


Figure 151—*de Forest* 0.25 *K. W.* 3 *Oscillion radiophone transmitter*

before, towers 200 feet (60 m.) high and 250 feet (80 m.) apart are presupposed.

Arrangements were made by the de Forest Company with a phonograph company whereby almost every night records made by this latter company were played into the radiophone transmitter and thus rendered audible to a wide circle of listeners. One or two oscillions are used in the transmitter, each with a stated output of 0.25 k.w. The wave length used has been 850 m. This service has been given about five nights per week since October, 1916. The music has been heard a number of times as far away as Buffalo, New York, a distance of 306 miles (490 km.) and even at an extreme range at Mansfield, Ohio, a distance of 465 miles (750 km.). One interesting result of this work has been a "radio dance" given one evening at Morristown, New Jersey, a distance of 30 miles (50 km.) from the de Forest station. Music was transmitted from the latter station and received at Morristown on a receiving set with a three-step audion amplifier. The resulting "signals" were sufficiently loud to permit the dance to be conducted. Another novel field for radio telephony, which Dr. de Forest believes presents great promise, is that of news distribution in rural districts. There is no doubt that the dissemination of information and various types of entertainment in districts which would otherwise be isolated is a most valuable possibility for radio telephony.

As is well known, the Western Electric Company has been carrying on extensive research work in radio telephony for some time past. (Some of the types of tubes described in the patents of that Company are similar to those shown in Figure 86. Generally speaking, platinum filaments coated with metallic oxids are there indicated.) A method of modulation of the output of such

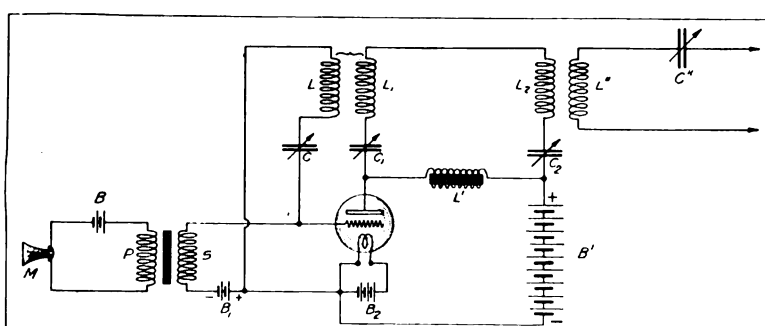


Figure 152—*Western Electric Company-Colpitts modulation system*, 1914

an oscillator has been developed by Mr. E. H. Colpitts. It is depicted in Figure 152. As will be seen, the plate oscillating circuit $C_1L_1L_2C_2$ is coupled inductively to the grid circuit CL at L_1. It is also coupled inductively to the output circuit $L''C''$ at L_2. A second grid circuit is also provided consisting of the secondary S of the audio frequency transformer, (the primary of which contains the microphone and battery B), and the battery B_1 for maintaining the grid at a negative potential. This system of modulation has the advantage of simplicity. On the other hand, it may easily become an unstable control system. The reason for this is the following: In any oscillating tube, the amplitude of the plate circuit oscillations increases until the losses in the tube, and in the external or output circuits which it feeds, utilize the entire available energy. The amplitude then remains constant. It is evident that if we make the grid potential extremely negative, so that the plate circuit oscillations cannot build up to this stable value just mentioned, the oscillations will simply cease entirely. Just above this extremely negative grid potential, there is a narrow range of grid voltages for which the plate circuit output depends on the grid potential, though only as a transient phenomenon. A static characteristic of such a relation between grid potential and oscillating current in the plate circuit is not obtainable because the effects do not persist. The oscillating current tends to rise either to its full and stable amplitude or to cease altogether. For audio frequency variations of moderate magnitude and sufficient rapidity of the grid potential the system is sometimes workable though always with the danger just mentioned for low tones or for extremely loud sounds.

A second system due to Mr. Heising* of the same Company is free from the objections mentioned in that the tube is used as an *amplifier* and not as an oscillator. The method in question is shown in Figure 153. The radio frequency source A impresses, through the transformer P_1S_1, corresponding radio frequency potential variations on the grid G_1 of the tube. There will, therefore, be produced in the output plate circuit of this tube radio frequency current variations. Hence there is an available output in the inductance L_2. The tube has a second grid G_2, and, as will be readily seen, there are impressed on G_2

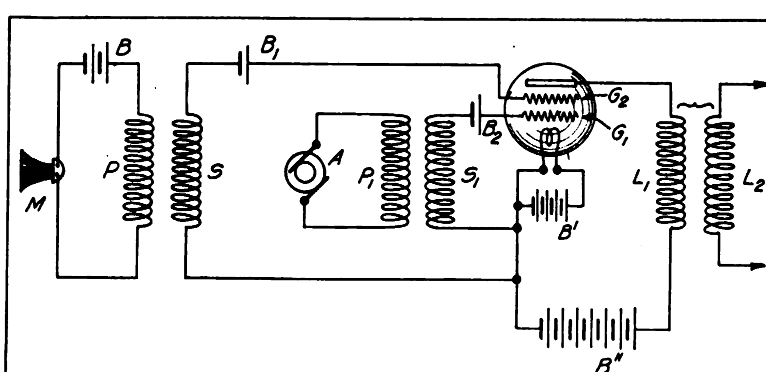


Figure 153—*Western Electric Company-Heising modulation control system,* 1915

potential variations corresponding to the speech amplitudes, these variations being produced in the customary way by a microphone circuit and a suitable trans-

* Patent 1,199,180.

former. The source A may naturally be a vacuum tube oscillator. Each grid is maintained at a suitable negative potential by the battery B_1 or B_2.

A series of long distance radiophone experiments were carried on by the Western Electric Company from the United States Naval Radio Station at Arlington, Virginia. This station has an antenna 600 feet (180 meters) high. Speech was transmitted by night from Arlington to the Eiffel Tower, Paris (a distance of 3,900 miles or 6,200 km. almost entirely over water), from Arlington to Mare Island, California (a distance of 2,400 miles or 3,800 km. overland), and from Arlington to Hawaii (a distance of 5,100 miles or 8,300 km., about half over water). While the transmission could be achieved only under exceptional conditions and was in no sense commercial, it is of marked interest in indicating how great a distance can be bridged by even a very moderate amount of power under favorable circumstances. One is reminded of the feat of Sayville, Long Island, in communicating with Nauen, Germany, a distance of 4,200 miles (6,700 km.) with only 6 kilowatts in the antenna.

The apparatus used at Arlington was constituted as follows: A small bulb (3 inches or 7.5 cm. in diameter) was used as a master oscillator. The filament was heated from storage batteries as usual, and the plate circuit was fed from 125 volts in dry batteries. The master oscillator had a fairly fine grid. Its output circuit was coupled loosely to the grid circuit of a 7-inch (17.7 cm.) "modulator" bulb with a coarser grid. Comprised in this grid circuit were a 150 volt battery, to give the grid the requisite negative potential, and the secondary of a 150-to-1 air core transformer in the primary of which was a button-type microphone and its supply battery. In this way, the voice potential variations were impressed on the modulator grid as well as the radio frequency variations. The plate circuit of the modulator was tuned, and included a 450 volt direct current generator.

The output circuit of the modulator supplied speech-modulated, radio frequency, potential variations to the fairly coarse grids of 7-inch (17.7 cm.) bulbs all connected in parallel. Their tuned output circuit in turn fed the coarse grids of from 300 to over 500 "power" bulbs in parallel. As before, these grids were kept at a constant negative potential of —150 relative to their filaments. The plate circuit of the "power" bulbs was fed from a large 600 volt, direct current generator which was normally used for the Poulsen arc at Arlington. A few turns of heavy copper band in this last plate circuit were inductively coupled to the tuned antenna. About 60 amperes at 6,000 meters wave-length were normally produced in the antenna, this corresponding to something over 6 kilowatts. The efficiency of the set was about 20 per cent. In running the set, fairly frequent bulb renewals were required, thus rendering a high upkeep cost of operation inevitable (according to one statement, $10,000 per month).

The apparatus used was mounted on a series of panels. The lower section of each panel had the necessary switches for controlling the filament and plate circuits of that section. The upper portion of each panel was in two halves. On each half were mounted 25 of the 7-inch (17.7 cm.) "power" bulbs, all cooled by air brought in ducts from a powerful blower. The cooling ducts were at the rear of the panel. All the bulbs on each panel portion were in parallel. Each bulb was provided with "Ediswan" socket base so as to be readily replaceable, i. e., all terminals were brought out through this base. The control and modulator bulbs were mounted on separate small panels.

We consider next a number of radiophone pliotron transmitters designed by the Research Laboratory and especially Mr. William C. White of the General Electric Company. The mode of producing reasonably constant sources of high potential (from alternating current supply) will be first considered.

The method referred to is illustrated in Figure 154. The alternator A sends current through the primary P of a transformer. This transformer has two secondaries. Of these one, S_2, is arranged to light the filaments F_1 and F_2 of two kenotron rectifiers. There are comparatively few turns in the secondary S_2 because the filament voltage is low. A second secondary S_1 is of many turns so as to furnish a high voltage to the plates P_1 and P_2 of the kenotrons. It will be noted that there is a central tap of the filament-feeding secondary S_2 the purpose of which is explained in connection with the description of Figure 64. It prevents injuriously excessive addition of the filament-heating and thermionic currents in either end of the filament. The middle point of the secondary S_1 is connected to one side of a large high voltage condenser C (e. g., of several microfarads), the other side of which condenser is connected to the middle point tap of the filament-heating secondary S_2. It will be seen that the condenser will be charged during one half of the cycle by the left hand half of S_1 in series with kenotron K_1 and during the other half of the cycle by right hand half of S_1 and the right hand kenotron K_2. If the current drawn from the charged condenser is comparatively small (which will be the case if the condenser is very large and a small current at high voltage is drawn therefrom), the potential difference at its terminals

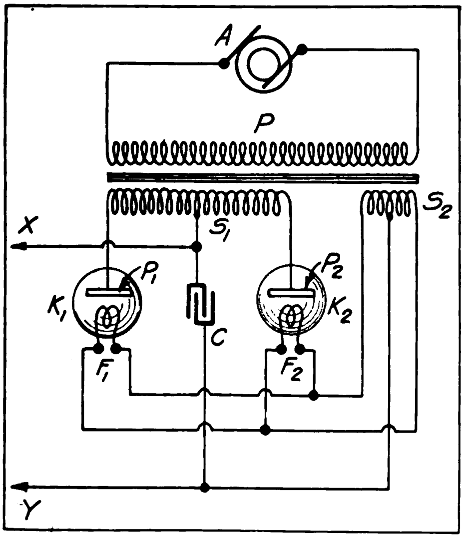


Figure 154—*General Electric Company-White method of producing practically constant potential from A. C.*

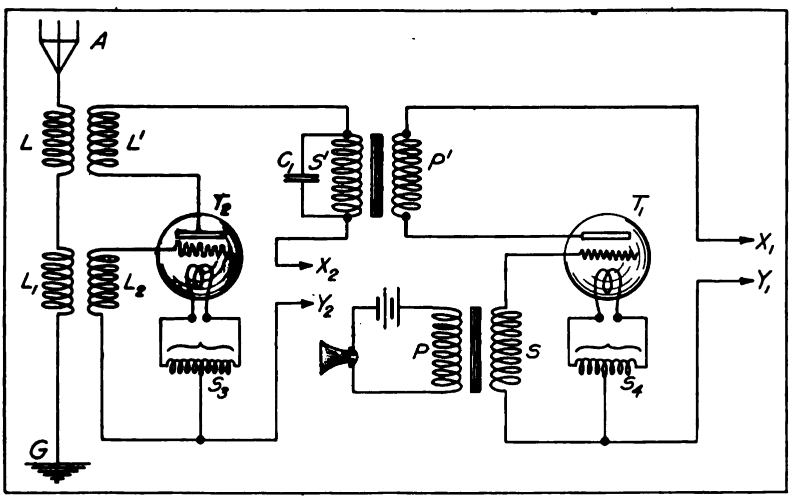


Figure 155—*General Electric Company-White radiophone transmitter for alternating current supply*

will remain appreciably constant. Experience shows, indeed, that this is the case, and it has proven possible to get so nearly constant a potential from an alternating current supply in this way that, when used in the plate circuit of a

normal pliotron oscillator, the normal a. c. hum has been practically absent. The output is drawn from the condenser terminals, *X*, *Y*.

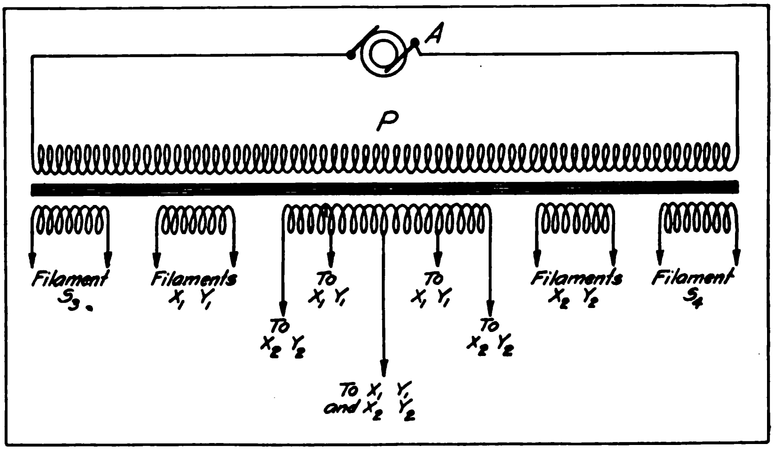


Figure 156—General Electric Company-White multiple transformer for feeding plate rectifier and filaments

Two of the earlier types of radiophone transmitters based on this principle will be next described, the description being due to Dr. Irving Langmuir of the General Electric Company.*

"The first outfit has a capacity of about 20 watts in the antenna, the source of power being the local city supply, which is 118 volts, 60 cycle current. This is connected with the primary of a small transformer having two secondary windings. One of the secondaries is designed to give about 5 volts and furnishes the currents used for heating the filaments of the kenotrons and pliotrons. The other secondary of the transformer is wound to furnish a potential of about 800 volts. This is rectified by means of a kenotron, and serves to charge a condenser of about 6 microfarads. In this way, a source of high voltage, direct current is obtained in a very simple manner. The plate of the pliotron oscillator is then connected to one of the terminals of the condenser, while the filament is connected to the other. The plate of the second pliotron is connected to the grid of the first, while the grid of the second is coupled by means of a second small transformer to the microphone circuit. With this small outfit, both pliotrons may be relatively small. . . . . .

"In the second outfit, which is suitable for use up to 500 watts or more, the high voltage direct current is obtained from a small, 2,000 cycle generator. The current from this is transformed up to about 5,000 volts, rectified by kenotrons, and smoothed out by means of condensers. By the use of 2,000 cycle alternating current instead of 60 cycle, it is possible to store up large quantities of energy at a given voltage and with a permissible fluctuation of voltage, and thus obtain as much as a kilowatt or more of power in the form of direct current with condensers of moderate size. This high voltage direct current is used, as before, to operate a pliotron oscillator, the output of which is controlled by means of a small pliotron connected to the telephone transmitter. . . ." Wire-line-to-radio telephone transfer has been accomplished with such sets.

Another form of radiophone transmitter of the General Electric Company, will be seen that the grid of pliotron amplifier T_1 is connected to the filament through the secondary *S* of a transformer, the primary of which contains a

*Proceedings of the Institute of Radio Engineers, volume 3, number 3, Sept., 1915.

described in Mr. W. C. White's patent 1,195,632, is shown in Figure 155. It microphone and battery. The plate circuit is fed at X_1Y_1, by exactly the same form of device as shown at XY in Figure 154. For the sake of simplicity, this device is not here repeated in the diagram. The output of pliotron T_1 is fed into the plate circuit of pliotron T_2 through the audio frequency transformer $P'S'$. The secondary of this transformer is shunted by the condenser C_1 which acts as a practically perfect by-pass for the radio frequency currents in the plate circuit of T_2 without passing any appreciable quantity of audio frequency current from S'. It will be seen that the tube T_2 is an oscillator since its grid and plate circuits are coupled through the antenna circuit at L L' and L_1L_2. Obviously, the method of modulation control here shown is an extremely stable one. It consists in varying the plate potential of oscillator T_2 in accordance with the speech. This implies, however, the injection of considerable energy into the plate circuit of T_2 intermittently and hence the necessity for amplifier T_1.

For use with a radiophone outfit of this sort, a special transformer shown in Figure 156 may be used. This has the single primary P but a number of secondaries which supply the following circuits (starting from the left): filaments of the oscillator T_2, filaments of the kenotrons which feed the amplifier T_1, plate circuits of the kenotrons feeding the amplifier T_1 and the oscillator T_2 (at different voltages, and the greater for the oscillator), filaments of the kenotrons feeding the oscillator T_2, and filaments of the amplifier T_1. Thus the entire set is started by closing one primary circuit, an obvious advantage.

A radiophone transmitter for direct connection to 125 volt direct current circuits is shown in Figure 157. The plug at the left of the set is merely inserted (with correct polarity) into a lamp socket and the change-over switch thrown to "transmit" in order to start everything in the set. It will be seen that the set is self-contained. The usual microphone transmitter, which can be seen at a distance from the remainder of the set, is seen on the top of the box. Only direct current (obtained by bridging the microphone across a por-

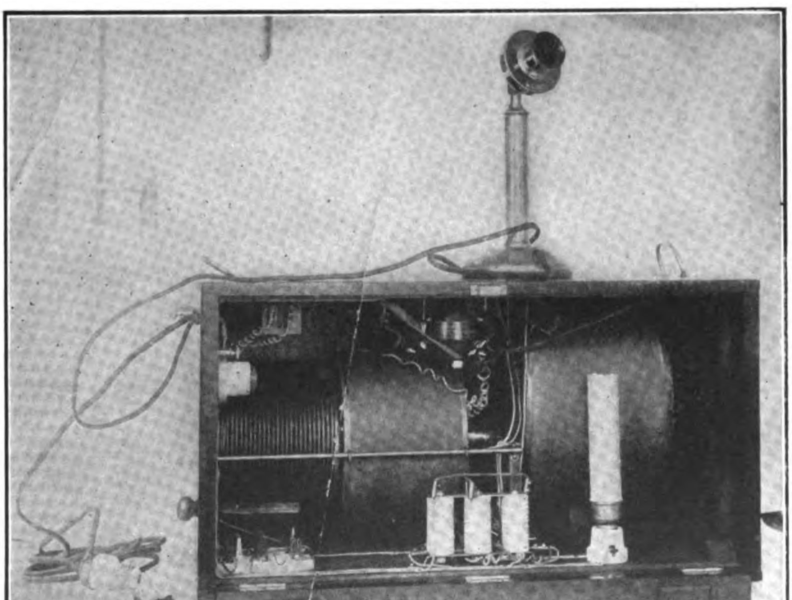


Figure 157—General Electric Company-White radiophone transmitter for direct current supply

tion of a 125 volt potentiometer) passes through the microphone. At the top of the box at the left is mounted a small fixed condenser which is placed across the feeding line to reduce commutator ripple and to act as a radio frequency shunt in the plate circuit. Thus the 125 volt current feeds the plate circuit of the pliotron which is mounted inside the various coils. The filament is lit from the 125 volt circuit through an appropriate resistance. These various resistances and potentiometer are shown in the foreground at the bottom of the box. The two left hand coils are the grid circuit coupling to the antenna and the coils at the right the plate circuit coupling, a circuit somewhat like that in Figure 155 being used. The entire set weighs only 54 pounds (20 kg.) complete. Completely sitisfactory operation over 10 miles (16 km.) is possible, and laboratory tests have given ranges up to 65 miles (105 km.).

A more powerful set for use with 60 cycle alternating current supply is shown in Figure 158. The wiring of this set is almost identical with that shown in Figures 154, 155, and 156. The two pliotrons are mounted at the top of the box. To the left, under them, are the microphone dry batteries. To the right, under them, are the "smoothing condensers" (two sets) for the high voltage supply in the plate circuits. To the bottom left are mounted the radio frequency coupling coils and to the right the four kenotron rectifiers. The panel in the middle carries various filament resistances, and back thereof are mounted

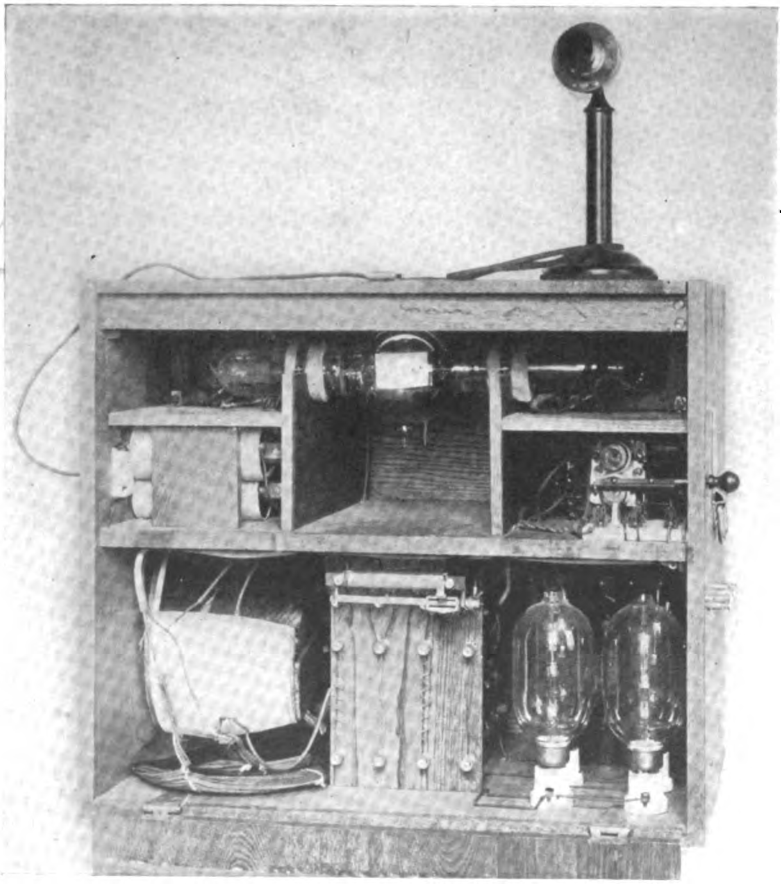


Figure 158—General Electric Company-White radiophone transmitter for alternating current supply

the microphone transformer (*PS* of Figure 155) and the amplifier transformer (*P'S'* of the same figure). The entire set weighs 150 pounds (68 km.). The transmitting range for satisfactory service is 50 miles (80 km.).

We consider next the control systems suitable for use with the dynatron and pliodynatron tubes of the General Electric Company as developed by Dr. Albert W. Hull. A description of the dynatron (and pliodynatron) together with their mode of operation is given in connection with Figures 87 through 90b, and the reader is referred to this material as an introduction to the present discussion.

Figure 159 represents the cross section of a dynatron where *F* is the filament, *A* the wires, or solid portions, of the anode, and *P* the plate. The paths of a few electrons away from the filament and a diagramatic representation of a few of the electrons leaving the plate by secondary emission are given for normal conditions in the left hand portion of the diagram. The effect on the electron paths of a longitudinal magnetic field (parallel to the filament) is shown in the right hand portion of the Figure. It will be seen that the electrons now pursue spiral paths and strike the anode very obliquely, particularly if the magnetic field is very powerful and the electron velocity small. In consequence, comparatively few will get through the anode with a high velocity, and therefore the re-emission phenomena from the plate will be much diminished. The characteristics of the dynatron will be progressively altered, as indicated in Figure 160, whence the magnetic field is increased. The dotted curve, *A*, is the normal dynatron potential-current curve. On applying a moderate magnetic field the dashed curve, *B*, is obtained. This shows no current reversal

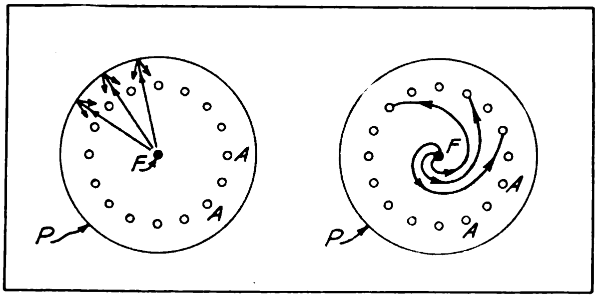


Figure 159—*Effect of longitudinal magnetic field on electron paths in dynatron*

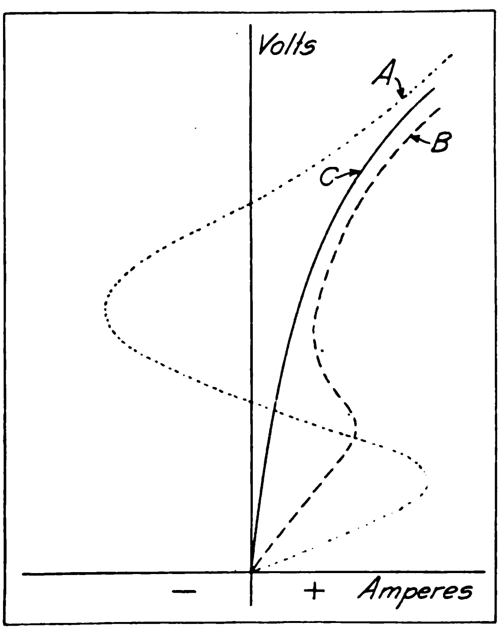


Figure 160—*Characteristics of dynatron in various magnetic fields*

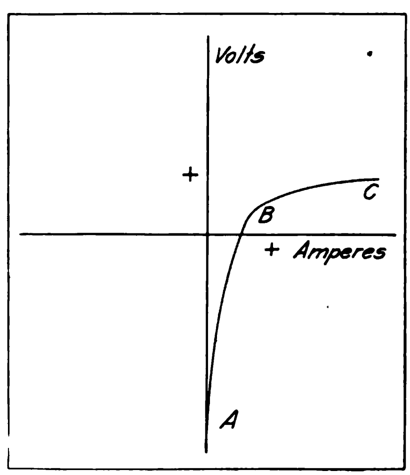


Figure 161—*Grid potential-plate current characteristic of a pliodynatron*

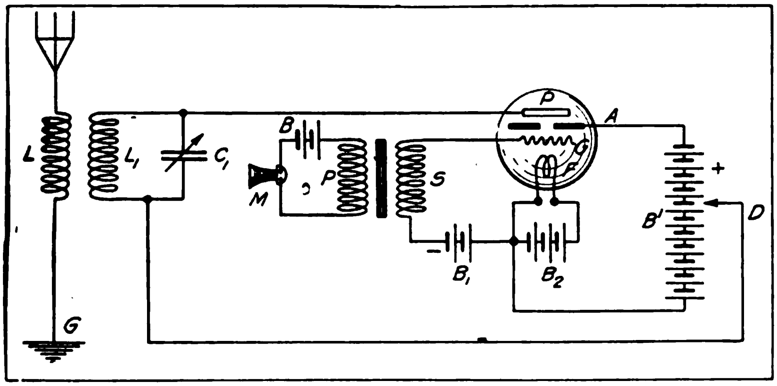


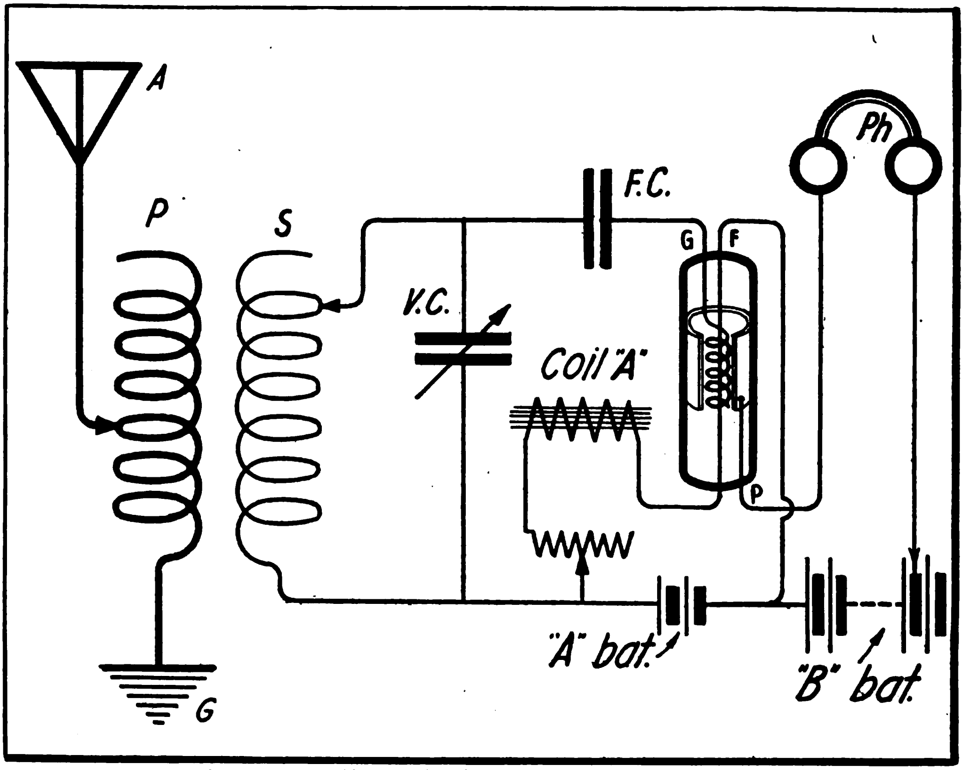
Figure 162—*General Electric Company-Hull pliodynatron radiophone transmitter*

since the secondary emission is already small. With a strong magnetic field, the charactertistic becomes the full line curve, *C*, and shows very little of the usual dynatron effect. It is therefore possible to control the negative resistance (and hence the output) of a dynatron by the superposed magnetic field, and this field may be that due to the current from a microphone transmitter passing through a coil suitably mounted relative to the tube.

The method of controlling the output of a pliodynatron would naturally be by varying the potential of the grid. Offhand it might seem that this would either stop all oscillations (if the grid were sufficiently negative) or else let them remain at full intensity. As a matter of fact, because of the curvature of the dynatron characteristic under certain conditions, it is possible to get a control curve of the pliodynatron (grid potential-plate current) similar to that shown in Figure 161. This curve has a considerable straight line portion, and consequently between A and B thereon, it becomes possible to control the output of the tube by varying the grid potential. The actual arrangement is shown in Figure 162. As will be seen, the circuit L_1C_1 is connected in the usual fashion for dynatrons between the plate and the battery tap point D. The potential variations corresponding to the speech are placed on the grid by the secondary S of the audio frequency microphone circuit transformer. The modulated output passes to the antenna circuit through the inductive or other coupling at L. In practice, radio telephony over a distance of 16 miles (26 km.) was easily accomplished with one pliodynatron; but this range could doubtless be much increased since no attempt was made at the time to get the greatest possible output or range.

This is the twelfth of a series of articles on "Radio Telephony," by Dr. Alfred N. Goldsmith. In the thirteenth article, to be published in the January issue, Dr. Goldsmith describes a system of radio telephone control involving both an Alexanderson alternator for the direct generator of the radio frequency energy and one or more pliotrons for the modulation and control thereof. He also takes up the ferromagnetic control systems wherein the magnetic properties or the iron cores of inductances are utilized.

Amateur Department



Drawing, an amplifying circuit for tubular vacuum valve detectors

An Amplifying Circuit for Tubular Vacuum Valve Detectors

I have found that the application of a magnetic field, as shown by the accompanying drawing, will increase the strength of incoming radio signals several times. It will be noted that the magnetic coil, A, is placed near to the tubular vacuum valve and is also connected in series with the circuit from the lighting battery. The core of soft iron is about 1½ inches in diameter, 3½ inches in length and is made up of a number of soft iron wires of the grade used for the cores of spark coils.

In practice, the magnet coil is placed about 1½ inches from the bulb and the strength of the filament battery is adjusted until a loud hissing noise is heard. Just below this point the signals come in very loud. Before I applied this arrangement to my apparatus I was hardly able to hear the time signals from Arlington, but after it was connected in the circuit and properly adjusted, I could hear this station with the phones lying on the table. My aerial is not very large; in fact, it is 80 feet in length and 55 feet in height. All my apparatus is home-made with the exception of the variable condenser and head telephone.

I have found this apparatus particu-

larly applicable for the reception of signals from amateur stations.

Peter Hansen, *Minnesota.*

An Efficient Station in the North

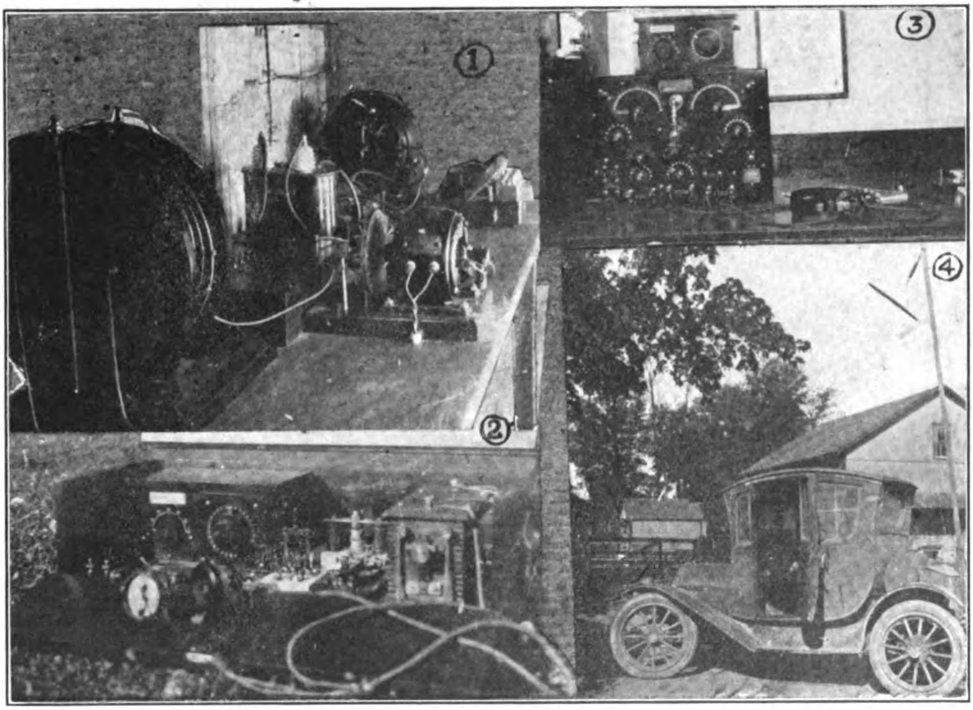
I know the readers of The Wireless Age are always interested in photographs of a first class radio station, and I therefore show in an accompanying photograph (1) the ½ K. W. transmitting set of 9 JV, the station owned by Macy Q. Teetor of Hagerstown, Ind. This amateur is only seventeen years of age and has been experimenting for about four years. The photograph shows clearly the closed core transformer, the high voltage condenser, rotary spark gap and the oscillation transformer.

Another photograph (2) shows a portable outfit mounted in a solid mahogany brass-point box which was designed by the same experimenter. It consists of a 2-inch coil, spark gap, key, condenser and eight dry cells, the latter being mounted in a separate compartment at the rear of the box. The entire equipment is representative of good workmanship and, to my knowledge, is one of the neatest portable sets yet constructed by an amateur experimenter.

The operating room is shown in the photograph numbered 3. The receiving set, head telephones and operating key are placed in this room. The receiving apparatus has a range of from 200 to 35,000 meters and receives damped and undamped waves. A control apparatus for the transmitter is mounted in this room in an accessible place near to the transmitting key.

This amateur mounted an experimental portable outfit on a Paige-Detroit coupe and after a series of experiments, succeeded in covering a radius of 4 miles with the small aerial mounted on the chassis shown in the photograph numbered 4.

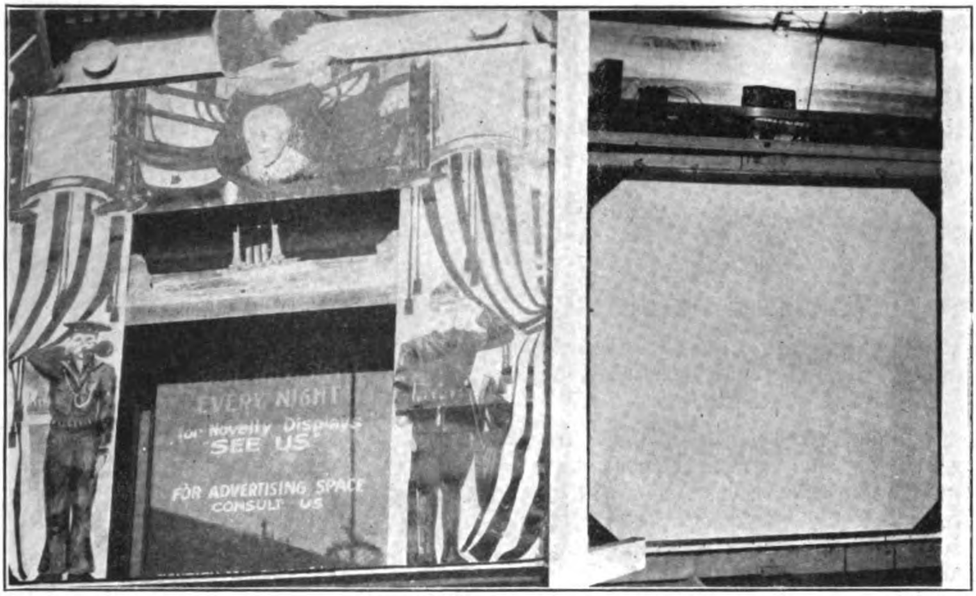
R. A. Dio, *Minnesota.*



In these photographs are shown the wireless apparatus of Macy Q. Tector, a young amateur of the Middle West

Wireless Apparatus and Advertising

A Los Angeles inventor has perfected an apparatus which uses a wireless call



Views of an apparatus which uses a wireless call to draw attention to an advertising window. Pictures are displayed on the screen (shown in the photograph at the left), and as they are changed S O S appeals are flashed

to draw attention to an advertising window. The window has been equipped with a screen 6 feet square, upon which pictures are projected by means of a machine located on the inside of the room. This machine has twenty slides, and as the projector slowly revolves the various pictures are thrown on the screen. Each picture is held on the screen for fifteen seconds and as the pictures are changed, S O S calls are thrown from the masts of the battleship. The spark can be distinctly seen midway between the two masts in photographs.

A condenser made of plate glass and tinfoil causes the S O S call to produce a long drawn out, weird, crackling noise which attracts attention to the battleship. Two S O S calls are sent out and the projector operates in conjunction with the wireless apparatus, so that as soon as the wireless call is stopped the next picture is flashed on the screen and held for fifteen seconds. The S O S call is flashed again during the change to the next picture. Passersby watching the battleship necessarily see the picture which is thrown on the screen. Each of these pictures is an "ad," and, of course, these "ads" not only make a vivid impression upon persons watching them, but the attention of practically every person passing along the street is attracted because the weird noise of the S O S causes them to search for the source of the crackling sparks.

A small motor gives the battleship an oscillating movement as if it were in a heavy sea. The waves are produced by a mechanical effect, also operated by the same small motor, and at night the sky effect produced by lights and painted canvas gives a very vivid impression of a ship sending out appeals for aid.

The projector and all machinery are set in motion and stopped by means of a clock arrangement. It can be started, say, at six o'clock in the evening and will automatically stop at any hour desired without the presence of an operator, the entire operation being automatic.

The projector is operated by a small electric motor. The clock turns on and off the power that operates the S O S calls and the projector at any set time.

CHARLES W. GEIGER, *California.*

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A ½ K. W. 500 Cycle Motor-Generator and a ½ K. W. 500 Cycle High Voltage Transformer

Frequently I have observed, in THE WIRELESS AGE, the request from readers for the details of the design of a ½ K. W. 500 cycle motor-generator set. Realizing that the amateur would have some difficulty in obtaining these data I prepared a set of specifications which I believe will give a machine of good efficiency. The limitations of the experimenter's work-shop and the material he has on hand have been given thorough consideration.

In presenting the method of construction of this generator reference is first made to Figure 1. The laminations for the stator should be cut or stamped out of .014-inch silicon steel sheets and the loss should not be more than 1.2 watts per pound of material at 500 cycles. Approximately 186 sheets will be required. The laminations for the rotor should be cut from the same material. One hundred and eighty-six sheets will here be required.

The stator space block should be made of cast iron, 12⅝ inch outside diameter and 8⅝ inch inside diameter, finished, by 4 inches long. Four holes, ½ inch in diameter, should be bored equidistantly around circumference ½ inch from the outside edge. Through these should be driven 4½-inch bolts, leaving 3½ inches projecting on each side.

Next, lay the stator laminations in the circle made by the bolts until ninety-three pieces are placed. Then put on the end clamp shown in Figure 4 and set up the nut until they are fairly tight. Next, reverse the space block, put in the other half stator iron-end-clamp and set it up in the same way. Next in the order of construction is to put the space block in the press and set it up until the spread of each stator pole is 1.5 inches. Make sure that all poles are in line when looking along the shaft. Then take up the nuts and the stator is ready for the coils. The method of clamping laminations is shown in Figure 2.

The coils, which are wound on a form ¾ of an inch by 1 9/16 inches consist of three layers of seven turns each of No.

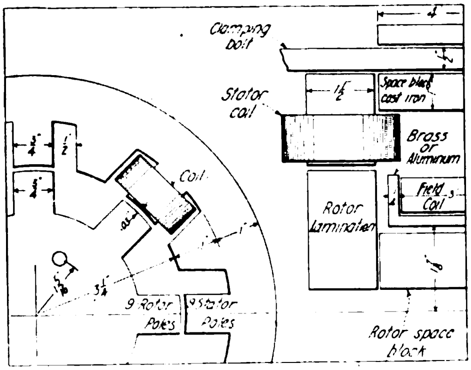


Figure 1, First Prize Article

12 B. & S. D. C. C. wire. If possible, stranded wire should be employed. Cover each coil with two layers of armature tape. Bring the leads out in "sleeving" and dip the coil into insulating paint, allowing it to dry. Place the coils on the poles, connect up alternating north and south in the proper way, and bring out the ends through holes in the end clamps with flexible rubber-covered cable. Before placing the coils, it will be necessary to grind out the inside face of the stator poles in a high speed rotary grinder.

The field coil holder is to be made of

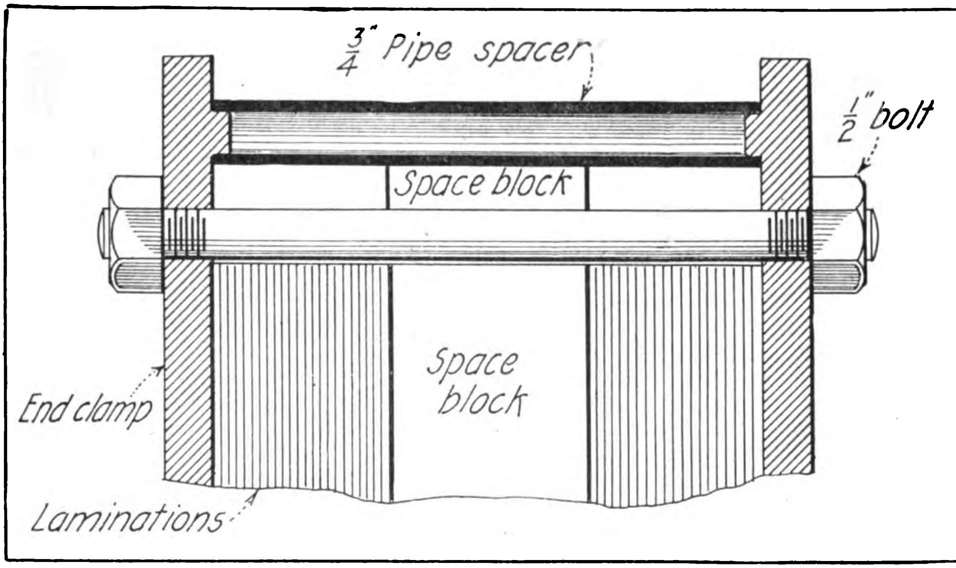


Figure 2, First Prize Article

brass after the dimensions shown in Figure 1. Three equidistant slots must be cut in the outside rim to a depth of ¼ of an inch and a width of ½ inch. Two rows of ½-inch holes are to be drilled in the bottom of this; there should be about four holes in each row.

The rotor space block should be made of cast iron after the dimensions of Figure 3. Drive in a piece of 1-inch shafting until one end of the shaft projects two inches. Fine threads should be cut, beginning at a point 1½ inches from the block for a distance of ½ inch. Turn down the shaft for the remainder of the distance, 1½ inch on one side and 3 inches on the pulley end, making the latter ¾ of an inch in diameter.

Then put on the ninety-three rotor laminations and screw up the rotor clamp fairly tight. Slip on the field coil holder over the rotor space block, put on the laminations of the other rotor pole and place the second rotor clamp after making sure that poles are in a line along the shaft. Place it in a press and set up until the face of each rotor pole is 1½ inch measured along the shaft. Place the rotor in a grinder and grind to smoothness. This grinding must be carefully done as the air gap must not exceed .03 inch.

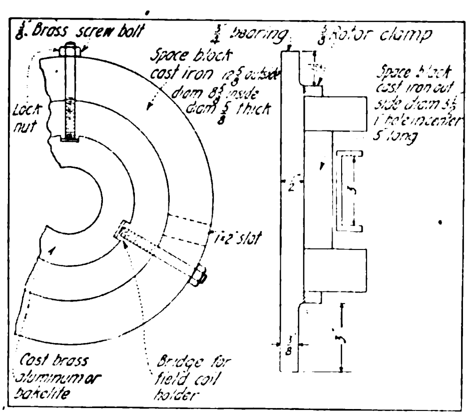


Figure 3, First Prize Article

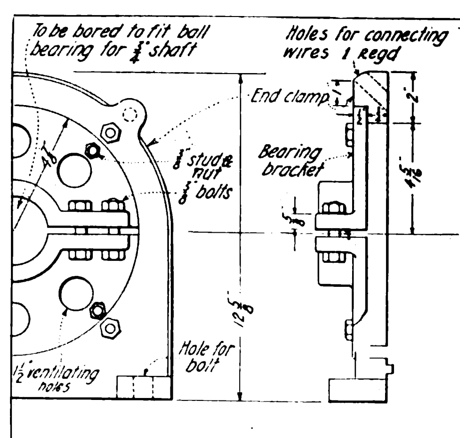


Figure 4, First Prize Article

The rotor should now be balanced by drilling the rotor space block through the holes in the field coil holder. Wedge the field coil holder in a central position by means of wooden wedges and insulate it; then wind on 13,000 turns of No. 33 B. & S. wire, bringing out rubber covered leads about two feet in length. The latter should be made of No. 18 wire. Next, place the three field coil holder bridges in position and fasten in place as shown in Figure 5. Follow this by cutting the key slot on the pulley end and give the field coil two coats of insulating paint. Then remove the wood wedges. Finally drive on a set of ball bearings and the rotor will be complete.

The assembly is as follows: Lay the field coil leads in spaces between the rotor poles and insert the rotor in the stator, fishing the field leads through the holes in the top of the stator space block. Next, put on the lower halves of the bearing brackets and see that the edge of the stator pole lines up fairly with the edge of the rotor pole. Put on the top halves of the bearing brackets and tighten up all bolts. I have given no dimensions for the inside bore of the end bearing brackets as they will be governed by the outside diameter of the ball bearing. The shaft will probably have to be turned to a different diameter to suit the ball bearing, but the writer does not recommend less than ¾ of an inch. Now put the field coil holding screws in place and center the field coil by sighting through the ventilating holes in the bearing brackets; then tighten up on the lock nuts, as shown in Figure 3.

The dynamo can now be belted or directly coupled to a direct or alternating current motor, or gasoline engine. It should revolve at a speed of 3,330 revolutions per minute to give a frequency of 500 cycles. The efficiency will be approximately ninety per cent. The constructor is cautioned to give particular attention to the fitting of the ball bearings to the shaft, the bearing brackets to the end clamps, and the grinding of the stator and rotor. The balancing of the rotor will be found to be particularly important.

In connection with this generator, the specifications of a ½ K. W. 500 cycle high voltage transformer are given. The primary voltage is 110 volts and the secondary 6,600 volts. I shall not give the details of construction as they have been described so fully in previous articles in this magazine.

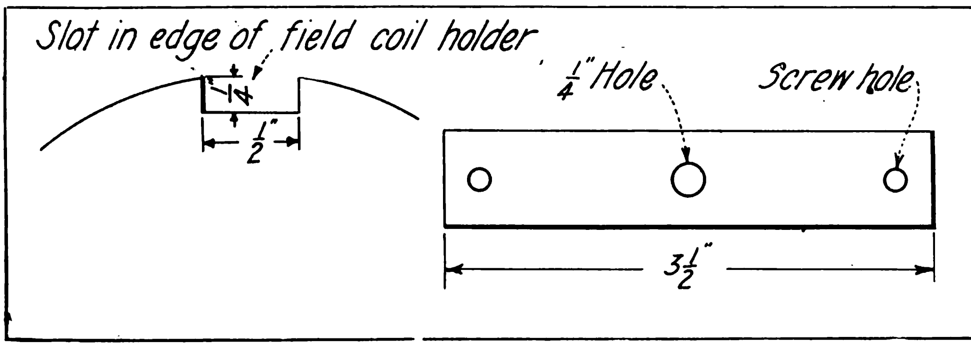


Figure 5, First Prize Article

The core of the transformer is made of silicon steel .014 inch in thickness, of a quality that will give 1.2 watts per pound loss, at 500 cycles. It will be 1.7 inch square in cross-section and 6.5 inch outside length. The inside length will be 3 inches, and totally, there will be required about 15.2 pounds of iron. The loss will approximate 20 watts.

The primary core is wound with empire cloth to a depth of .25 inch, and the primary winding consists of 120 turns of No. 12 B. & S. D. C. C. wire wound in four layers of thirty turns each. The resistance will be about .17 ohms and the I^2R losses approximately 9.5 watts.

The secondary winding is insulated from the core by a winding of empire cloth having a depth of .25 inch. The same thickness is used between coils, and

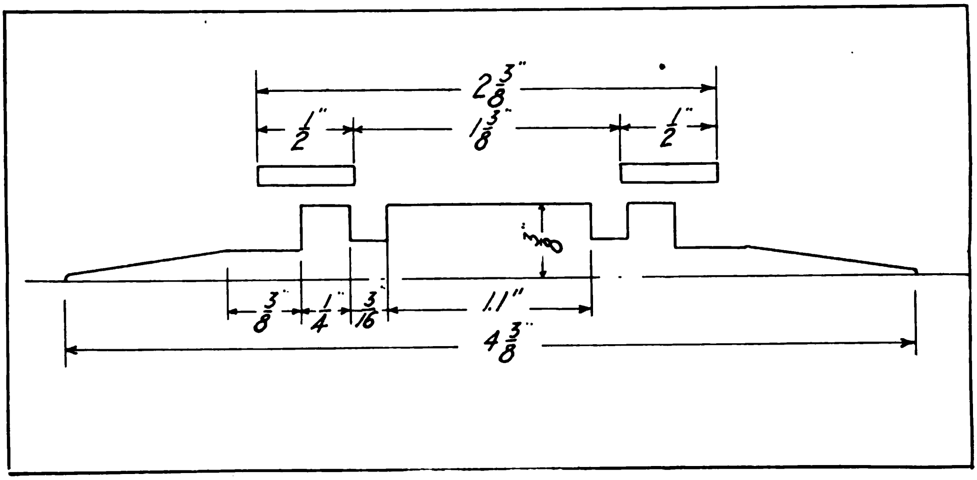


Figure 6, First Prize Article

between coils and core. Seven thousand two hundred turns of No. 28 wire wound in two sections of 3,600 turns each will be satisfactory. This will require about four pounds of wire with a resistance of 424 ohms. The I^2R losses will be seven watts and the efficiency ninety-three per cent. The primary current should approximate 7.75 amperes and the secondary current .125 ampere. This transformer is designed to be operated ten per cent. off resonance. The condenser to accompany this transformer can be constructed as follows: If we allow seventy-two square inches of dielectric for a capacity of .001 microfarad, considering the thickness of glass ordinarily used, we require eight plates, and inasmuch as the voltage of this transformer is low, photograph plates ⅛ of an inch or .125 inch in thickness will be satisfactory.

The primary winding of the oscillation transformer should be 10 inches in diameter and consist of four turns spaced one inch apart. The winding should be made of ⅜ of an inch copper tubing mounted on porcelain. The secondary winding should be made of 8 turns, 8 inches in diameter, spaced ¾ of an inch apart and made of copper tubing ⅜ of an inch in diameter. Any type of oscillation transformer having primary inductance of 1.4 microhenries can be employed.

The apparatus can be mounted on a panel if the builder desires, and it will not cost very much to construct. All the patterns required for the construction of this apparatus can be made in the average amateur workshop. The most difficult part will be the stamping out of the slots in the stator and rotor. Further difficulty may be experienced in grinding the stator and rotor iron after assembly.

I have shown in Figure 6 a half section of a spark gap plate suitable for this set. The plates will have a separation of ten mils and there will be approximately 1,100 volts per gap. Six gaps, which may be made of brass or copper, will be required. The washers between plates should be made of mica. About one pound pressure should be placed upon the plates by a 6-inch wrench with a thirteen-thread screw. The sparking surface of the gap should have a sparking surface of silver sweated on.

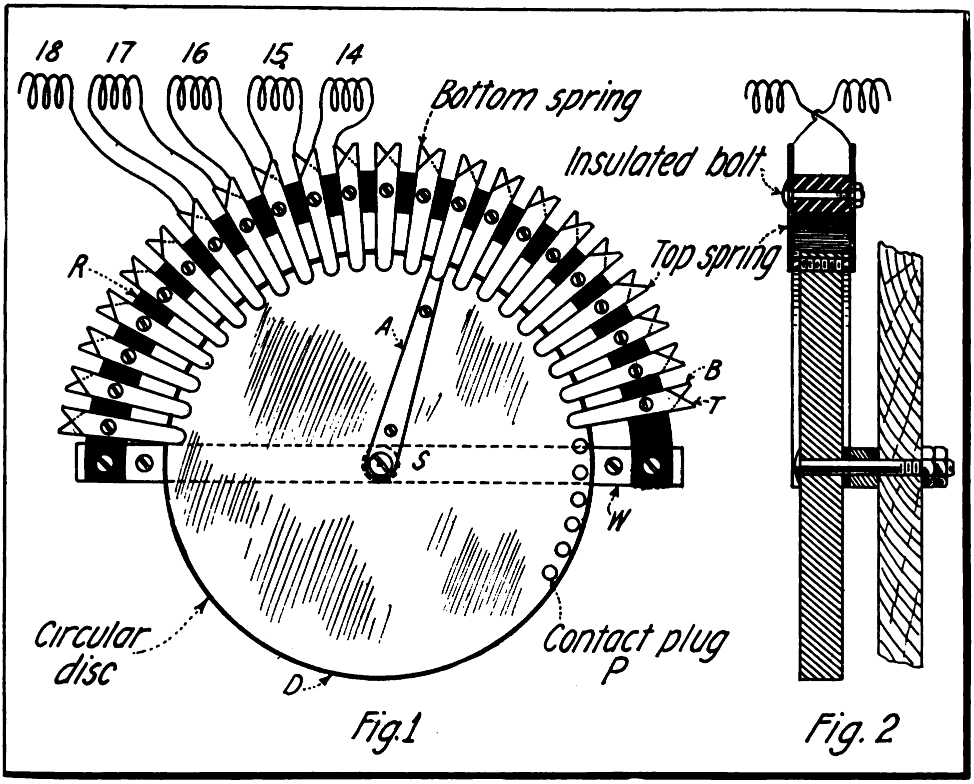
JOHN J. HOLAHAN, *Virginia.*

SECOND PRIZE, FIVE DOLLARS

The Elimination of End-Turns in Receiving Transformers

This article describes a dial switch for a wireless receiving set, the purpose of which is to eliminate dead-end resonance effects.

A circular fibre disc, D, mounted on an insulating support, W, carries near its outer edge a series of metal plugs, P, threaded into the disc so that their ends are exposed on both sides of the disc.



Drawings, Second Prize Article

These plugs make contact with a series of springs mounted on both sides of a semi-annular fibre ring, R, mounted concentric with the disc but fixed in position. Figure 1 shows the switch in plan and Figure 2 shows an enlarged cross-section. The row of plugs extend nearly but not quite half-way around the disc. There should be as many sets of contact springs on the ring as there are plugs on the disc. The springs and plugs should be accurately and uniformly placed.

In this particular switch the plugs were made from a piece of No. 6 copper wire threaded its entire length with a standard die. The holes in the disc were drilled and tapped with a standard thread. The end of the wire was then screwed into a disc until it projected slightly through the other side of the disc. The wire was then cut and the detached plug in the disc was filed down almost even with the surface of the disc and then rounded. All the plugs were inserted and finished in this manner.

The contact springs on the ring, R, are made from .013-inch spring copper cut in strips one inch long and tapering in width from 3/16 to 1/8 inch. These are bolted with insulated bolts to the fibre ring, with their narrow ends toward the center. As shown in Figure 2, there is a top and a bottom spring to each set. Both springs make contact with the same plug at the same time, but as the disc is rotated, each plug makes contact with each and every set of springs. The spacing of plugs and springs should be accurate and uniform.

The primary of the receiving transformer is cut in sections of thirty turns each, the ends of each section being brought out to the switch, and then soldered to the contact springs. As shown in Figure 1 the right terminal of each section of the coil is soldered to the bottom spring and the left end terminal of each is connected to the top spring. If, now, the top and bottom springs are brought in contact with each other, two

adjacent sections of the coil are thrown in series. This is accomplished by turning the disc until a plug is brought between the two springs. As the disc is further turned to the left, another section of the coil is placed in series with the first two. It will be noticed that each plug takes the place of the preceding one, thereby maintaining a series circuit as more are connected in by the leading plug. That part of the winding not in use is left open, in small sections, and therefore it cannot resonate except to exceedingly short wave lengths.

A strip of metal, A, extends from the central screw, S, to the leading plug, which makes contact only with the springs on the top. This brings each coil completely into the circuit at once. The end section of the winding (No. 1 in this case), was connected to a plain dial switch having thirty taps. This provides the necessary closeness of adjustment for accurate tuning.

H. D. McMurtray, *Mississippi.*

THIRD PRIZE, THREE DOLLARS

The Design of a 150 Watt Step-Down Transformer

A step-down transformer delivering convenient voltages is a requisite addition to a well-equipped amateur laboratory. The one described in this article is designed to operate, directly, on the 110 V. 50-60 cycle current.

Beginning with the core, it should be made of silicon and the laminations should be staggered. The core pieces are 1 inch by 4 inches and 1 inch by 3 inches

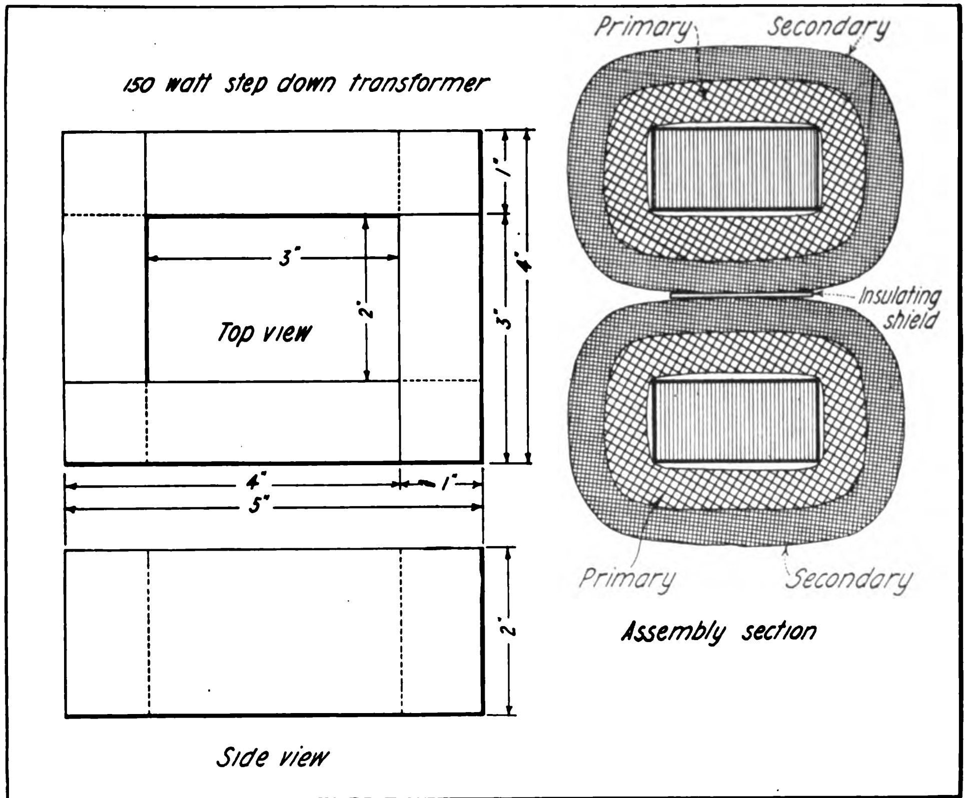


Figure 1, Third Prize Article

and should be built up 2 inches high, which gives a rectangular cross-section, as shown in Figure 1.

The longer legs are securely taped while tightly compressed to fully 2-inch thickness. The end legs are then removed to facilitate winding.

The primary coil consists of 360 turns of No. 18 D.C.C. wire and will require 2¼ pounds. This allows continual operation within the rated capacity. Three

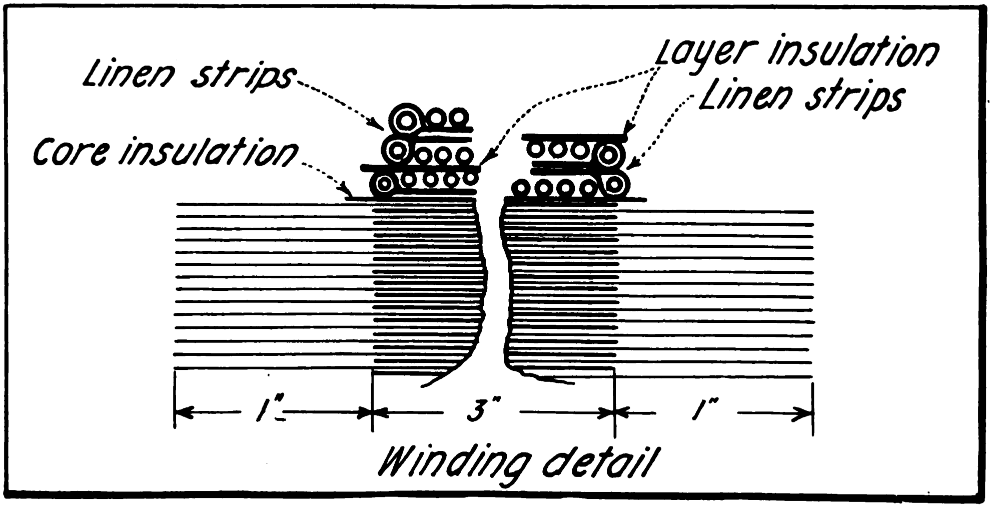


Figure 2, Third Prize Article

hundred and fifteen turns are wound on each leg and the two windings are connected in series (See Figure 1).

The winding of these coils is most easily accomplished in a lathe, but a serviceable jig can be made of wood as follows: One-inch blocks are fitted to the ends of the core to be wound by cutting niches 1 inch by 1¾ inches to a depth of ½ inch. A small machine screw projecting through the center of one block serves as a bearing for that end and a small crank, the other. The core with blocks attached is supported on uprights which are fastened to a suitable base. A piece of hard wood, having its upper edge round and in line with the axis of the core, should be set up on the base several inches in front of the core. This serves as a guide and also places a tension on the wire and therefore removes all kinks as it is wound.

Fiber end plates could be fitted to the core, but the following method allows much better ventilation: First insulate the core with several layers of 4-inch empire cloth strips. Then, taking one of the narrow sides as the top, the first turn, having a piece of ¾-inch linen tape looped over it, is placed 1 inch from the ends of the core. The following turns are then wound over the linen strip, thus holding the first turn in position. (See Figure 2). The first layer continues to within 1 inch of the other end of the core, which gives approximately a 3-inch layer which should contain 315 turns. The last turn is placed first to try the fit and then unwound and a 1-inch strip of thin linen cloth or empire cloth folded over it, edgewise or "U" shaped, and wound around with it, with the edges lying back on the former turns. This strip continues with the next turn which is wound directly over the other and as near the edge as possible. The following turns bind the edges of the linen strip firmly in place which keeps the end turns from falling down. (See Figure 2). This operation is repeated at the end of each layer.

It is best to wind four or five layers of manila wrapping paper between layers, extending from the edges of the linen. This compensates for the additional thickness caused by the linen strips and provides the insulation as well. The primary must not be allowed to bulge at the sides as the finished height from the core, in order to leave space enough for the secondary, should not exceed 9/16 of an inch.

The secondary consists of two pounds of No. 12 D.C.C. wire, or approximately 210 turns. The primary is insulated by eight or ten layers of wrapping paper followed by winding 210 turns over each leg. The ends of the layers are held in place as in the primary. Leads are brought out at the 35th turn, 70th turn,

and the 105th turn or the end, on each leg. These are made by soldering the hooked end of a ½-inch strip of copper ribbon (not smaller than 24 guage) to the proper turn.

The following table gives the data regarding the switch connections:

Point No.	Effective No. Turns	Voltage	Connections	
1	35	6	2 groups,	35 turns in parallel
2	70	12	2 groups,	70 turns in parallel
3	105	18	2 groups,	105 turns in parallel
4	140	24		140 turns in series
5	175	30		175 turns in series
6	210	36		210 turns in series

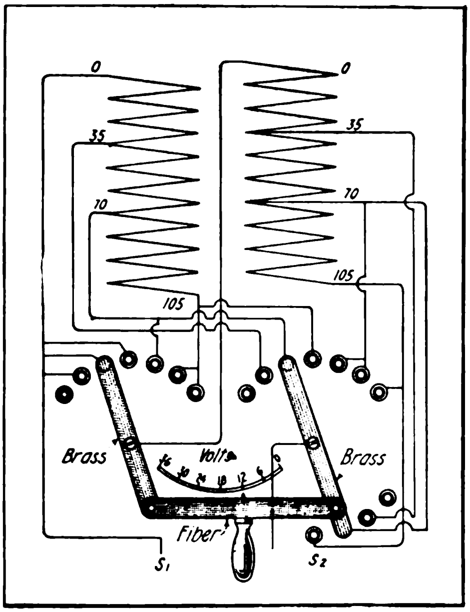


Figure 3, *Third Prize Article*

Both legs should be wound in the same direction and when "setting up" the beginning leads should be diagonally opposite, otherwise the wiring circuits will not work out properly.

The switches should be designed so that the blades do not short adjacent taps. Fiber headed chair tacks can be alternated with the points to raise the blade slightly as it passes. The ends of the arcs should not come too closely opposite or the connecting lever will be almost on dead center when on the first and last taps.

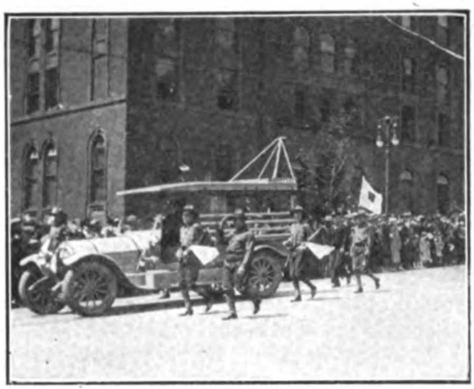
Figure 3 gives the connections and the general construction.

Allan Thompson, *California*.

The Albany Signal Corps Ready for Instruction Work

Following the publication of the article in the November issue of The Wireless Age calling attention to the need of the Government for instructors in wireless and buzzer work, H. G. Mulligan, Acting Commander of the Albany (N. Y.) Signal Corps has announced that the organization is qualified to take up this task, and offers its services.

The Albany Signal Corps was organized in the Spring of 1916 for the purpose of training its members in the signaling methods employed in the United States Army. Five of its members are in the Government service. Two are connected with the regular Army Signal



A view of the Albany Signal Corps' auto tractor set. This organization is prepared to aid the Government in wireless and buzzer instruction work

Corps at Camp Vail, Little Silver, N. J.; one is a sergeant in the 303rd Signal Battalion at Camp Dix; one is taking the Army signal course at the College of the City of New York, and the fifth member of the Corps is in attendance at the Navy Radio School.

The Corps is equipped with a large auto tractor radio set, a photograph of which is shown in the accompanying illustration. The apparatus is of modern design and includes a Paragon tuner and vacuum valve detectors. The mast, when erected, extends sixty-five feet into the air. It is employed with a counterpoise ground. The set has been dismantled since the declaration of war against Germany by this country.

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

A FORMER amateur of the United States is a member of the Naval Reserve of the Government of N. S. W., Sydney, Australia. He writes:

"I am mobilized for duty at the Sydney radio station (VIS), having joined the Naval Reserve some time ago as electrical artificer.

"The station is a standard 40 K.W. Telefunken plant with an umbrella aerial, 400 feet high. With the receiving set, which is a regenerative valve apparatus, 'POZ' is picked up each morning at about four o'clock and copied for several hours. That is some distance, isn't it? We heard WGG (Tuckerton), once, also Darien, Koko Head (KIE), Pearl Harbor, Funashashi (Japan) (JJC), come in good at all times. . . . . . .

"I have been a local subscriber to THE WIRELESS AGE for over two years, and think it one of the best."

* * *

How would you like to be the radio operator on a Zeppelin? You wouldn't mind, we assume, if it belonged to the Allies.

If we are to judge by what the New York Globe's war correspondent tells us, the problems of these mid-air radio operators and the general operation are no different from those encountered in ship work.

The L-49 was recently captured intact by the French authorities and the Globe's correspondent was one of the first to make an inspection of the Zeppelin after it had been taken under control by the French Government. It seems that when destruction or capture of the L-49 appeared imminent, the operator attempted to destroy the wireless apparatus. A French officer informed the correspondent that repairs could easily be effected as the damage to the apparatus was not great. The radio set of the Zeppelin, according to description, was not unlike that of an ordinary ship installation, and the appointments and general lay-out were a close duplicate of the commonly used commercial set. A passage way, 500 to 600 feet in length, ran through the Zeppelin.

* * *

Members of the N. A. W. A. throughout the United States who are available as instructors in wireless telegraphy, either in theory or in code practice, are requested to communicate with the association immediately.

There is urgent need for several hundred instructors in radio to assist the United States Government in preparing men for war service, and the N. A. W. A. desires to have a complete list of names on file. Amateurs are urged to give this matter prompt attention.

The Wireless Man's BOOKSHELF

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Over 2 lbs. up to 3 lbs..	6c	7c	10c	15c	.20	.25	.31	.36
Over 3 lbs. up to 4 lbs..	7c	8c	12c	19c	.26	.33	.41	.48
Over 4 lbs. up to 5 lbs..	7c	9c	14c	23c	.32	.41	.51	.60
Over 5 lbs. up to 6 lbs..	8c	10c	16c	27c	.38	.49	.61	.72
Over 6 lbs. up to 7 lbs..	8c	11c	18c	31c	.44	.57	.71	.84
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The text matter rapidly leads into more advanced experiments, complete data being given, for instance, for the construction of a wavemeter, and instructions for its use under all conditions. This includes tuning, the measurement of inductance capacity of a wireless telegraph aerial, and general methods of calibration. The measurement of the logarithmic decrement is treated in a way easily understood by the beginner. The design and working drawings for several types of low power transmitters are included, covering the construction of a quenched spark gap and apparatus associated therewith.

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L. B., Milwaukee, Wis.,:

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* * *

Q. V., Buffalo, N. Y.:

We regret that we do not possess detailed information concerning the construction of the Mignon undamped wave disc core radio controller. You probably can obtain this information by addressing an inquiry to the manufacturers.

* * *

J. A., San Juan, P. R.:

The standard Marconi receiving apparatus shown on the cover page of THE WIRELESS AGE is fully described in the book, "Practical Wireless Telegraphy" which can be purchased from the Wireless Press, Inc., 25 Elm Street, New York City.

We do not know the composition of phonographic records because in the majority of cases these records are made by a secret process. We do not, in fact, know the insulating qualities of this material or whether or not it would be preferable to hard rubber, for instance.

Answer to third query: Complete diagrams of crystal detectors and associated apparatus appear in the textbook, "Practical Wireless Telegraphy."

Answer to fourth query: You may use brass or any other metal for the plates of a variable condenser. Sheets 1/32 of an inch will be more satisfactory, as they are not so apt to warp.

The notation, "6 amperes," on a fuse plug means that the fuse will burn when current in excess of six amperes passes the circuit. The circuit will then be automatically opened and the line protected.

* * *

H. T., Pt. Richmond, Cal.:

You are quite right in your recent correction. Silver, obviously, is not an insulator but a distinct conductor. The word "silver" in the list mentioned should in reality have been "sulphur."

Platinum and silver electrodes, not copper and silver, are the correct electrodes for the silver vollameter.

We regard the Omnigraph as a practical automatic sender and it will be found of great assistance to the beginner.

* * *

V. I. M., Denver, Colo.:

The actual number of sheets required for a fixed condenser of the capacity you mention will vary according to the dielectric of the insulating material employed. Assuming it to be paraffine paper, you should make up a condenser of twenty-four sheets of foil, 2½ inches by 2½ inches. Twelve sheets are connected in parallel on either side.

The capacity of the condenser, of course, will depend upon the pressure applied and it is preferable that it be clamped between two pieces of wood.

The following dimensions are applicable to a 6,000-meter inductively-coupled receiving tuner. The primary winding should be 12 inches in length, 7 inches in diameter, wound closely with No. 24 S. S. C. wire. The secondary coil should be 12 inches in length, 6 inches in diameter, wound closely with No. 32 S. S. C wire.

* * *

W. T. G., Danville, Va.:

The question of wireless range has engaged the attention of radio telegraph engineers for a number of years, and even with the large amount of data on the subject collected by various organizations and individuals, it can be stated that the reasons for the fluctuation of wireless telegraph signals at night are not thoroughly understood. The theories advanced have been discussed from time to time, but no definite conclusions have been arrived at. Your observations are in accordance with results obtained in other stations and it is a fact, as you state, that it will sometimes be difficult for a receiving station nearby to receive the signals from a given transmitter while at the same time another receiving station, 700 or 800 miles away, will be able to hear these signals with considerable strength. This phenomenon is more often observed on the shorter wave-lengths, such as 200

meters, than on the longer waves. It is quite probable, in a case of this kind, that the wave motion is reflected from the earth to the upper conducting shell above the earth's atmosphere, and if a receiving station happens to be favorably located in the torturous path of such a wave the aerial will receive induction therefrom, while another station 100 miles away, for instance, may receive no induction whatsoever.

You are advised to study the articles on the subject of radio range appearing in the September, October, and November, 1916, issues of The Wireless Age. The matter has also been discussed at some length in back issues of the "Proceedings of the Institute of Radio Engineers" and has received some attention in the "Year Book of Wireless Telegraphy and Telephony." The subject would require too much space for detailed discussion in these columns.

* * *

J. A., San Juan, P. R.:

A slight rearrangement of the design of your spark coil will result in greater efficiency. We advise, for instance, that the primary core for the 2½-inch spark coil be wound with 210 turns of No. 16 magnet wire which is again covered with several layers of Empire cloth. The secondary winding should be wound with about two pounds of No. 36 enamel wire split into two sections. The primary condenser will require fully 2,500 square inches of foil, and since your sheets are 10 by 5 inches you will require from fifty to seventy-five sheets which will be separated by paraffine paper.

The sample of wire you enclosed was No. 36 enamel wire, but much finer wire can be obtained for winding telephone receivers if you desire it.

We do not know whether the number indicated on your receiver case is a stock number or designates the resistance of the particular receiver. It is quite likely, however, that each ear piece has resistance of 1,250 ohms and the two in series, 2,500 ohms.

* * *

W. R. M., Bangor, Me., inquires:

Ques.—(1) Referring to the design of the receiving tuner given by John D. Coleman on page 849 of the August, 1917, issue of The Wireless Age, I do not fully understand the primary winding and its connections. How many turns are there on the complete coil?

Ans.—(1) There is an author's error in that article. The primary winding should have, when completed, ninety turns. The first ten single turns in groups of ten are brought to the points of an eight-point switch. By this method of connection the inductance of the primary winding of a receiving transformer can be varied from one turn to the maximum number which gives ease of control, does away with sliding contacts and permits flexibility of adjustment which is not otherwise possible.

Ques.—(2) Will the variable condenser shown in Coleman's diagram reduce the strength of signals? The reason I am asking this is that in the September, 1917, issue of The Wireless Age, page 937, John M. Clayton stated that a condenser cut across the secondary windings of a receiving tuner, when used with the vacuum valve on short wave-lengths, would reduce the signals by fifty per cent.

Ans.—(2) The variable condenser shown in the diagram is not, strictly speaking, a secondary condenser, for you will note that while one terminal is connected to one terminal of the secondary winding, the other terminal is connected to the top condenser, B, and therefore the two condensers are in series. We believe that the variable condenser shown in this diagram gives an additional electrostatic coupling between the secondary and wing circuit of the vacuum valve.

Answer to the last three queries: We cannot give you specific dimensions for the transformer shown in the book, "How to Pass U. S. Wireless License Examinations," unless we know exactly what condenser capacity is to be used and to what source of current it is to be connected. We can, however, offer advice on the matter of the primary winding. It should not be tapped at intervals, but the flow of current can be controlled by an external reactance coil which can be wound with the same size wire as the transformer.

* * *

H. H. S., Chicago, Ill.:

Data for a ½-K. W. cycle transformer appear on page 244 in this issue of The Wireless Age.

Answer to second query: A condenser capacity of .006 microfarad will do for the average 1 K. W. 500 cycle transmitting set provided the secondary voltage of the transformer is between 12,000 and 15,000 volts.

The dielectric constant of glass varies from six to nine, according to the texture.

A good average value of capacity for an amateur aerial would be approximately .00035 microfarad.

The form factor of an aerial can best be calculated by Mr. Blatterman's formula, published in the October, 1916, issue of The Wireless Age which is also published in the textbook, "Practical Wireless Telegraphy."

* * *

E. S. R., Toronto, Canada:

We do not know whether you will be able to obtain the exact working dimensions for the construction of a Brown amplifying relay.

The coils, L-1 and L-2, in Figure 181, page 160 of "Practical Wireless Telegraphy," can have about the same dimensions as the ordinary loose coupler constructed for the wave-length of 300 meters.

* * *

C. F. L., Milton, Mass.:

The problem of high speed mechanical circuit interrupters for use with induction coils has not yet been solved. Engineers

and inventors have experimented for a number of years, but so far they have not developed a mechanical or electromagnetic interrupter that will handle more than a kilowatt satisfactorily. The electrolytic interrupter operated from a direct current source gives a very high pitched note and a spark of considerable volume at the secondary winding of the induction coil, but this interrupter will not operate continuously without frequent attention. To be more exact, interrupters of all types operate most efficiently at powers less than ½ K. W.

You should have no difficulty in understanding the meaning of the term K. W., for the prefix, "kilo," simply means 1,000, and consequently, a kilowatt is 1,000 watts. It can also be shown that 746 watts equal one mechanical horse power, therefore, 1 K. W. equals approximately 1-1/3 horse power. See the book, "Practical Wireless Telegraphy" for a more detailed explanation.

* * *

C. M., Watertown, Conn., inquires:

Ques.—Is it possible to construct a synchronous gap which is driven by a small alternating current motor, revolving at the same speed as the generator, and by putting the same number of studs on the disc as there are field poles on the generator?

Ans.—It is possible to obtain synchronous adjustments with a spark gap driven in this way, but difficulty is encountered when a load is thrown on the driving generator, due to the drop in voltage. It is quite possible that, when the telegraph key is closed, the generator armature and driving power will not reduce their speed in the same ratio as the motor of the synchronous gap. Hence, the gap motor and the generator would not operate in phase and the discharge would be non-synchronous. Independently driven synchronous rotary spark gaps have been employed commercially, and, we believe, were originally supplied to the trade by the International Telegraph Construction Company. Their use, however, has been discontinued. It would be well for you to take note of the fact that a 60-cycle synchronous spark gap set does not give as pleasing a spark note as the non-synchronous rotary gap, although it will be clear and uniform.

* * *

M. T., San Antonio, Tex. :

Super-sensitive receiving sets of various types are described in the last edition of the book, "How to Conduct a Radio Club," which can be purchased from the Wireless Press, Inc., 25 Elm Street, New York City. The circuits of such apparatus are also considered in the textbook, "Practical Wireless Telegraphy."

* * *

A. D. Z., St. Paul, Minn., inquires:

Ques.—(1) What type of receiver is employed by the United States Navy for the reception of undamped oscillations?

Ans.—(1) We understand that the three-electrode vacuum valve inserted in a special navy regenerative circuit is employed.

Ques.—(2) Is there any advantage in using a number of three-electrode vacuum valves in cascade?

Ans.—(2) A decided advantage is obtained by connecting the valves in this way, particularly if they are employed to amplify radio-frequency currents. The utility of such a method of connection was shown in a United States patent granted to G. Nicholls where a static eliminator was employed to balance out atmospheric electricity, and, due to the fact that the incoming radio signals were weakened by this process, steps were taken to bring them back to their original strength and increase their amplitude by means of several valves connected in cascade. There is another advantage in the cascade connection in that it increases the selectivity of the receiving set, much sharper tuning being obtained by this method than by the single circuit.

Ques.—(3) Where can I obtain information regarding the Marconi tubular steel masts?

Ans.—(3) The construction of these masts is described in the textbook, "Practical Wireless Telegraphy, on sale by the Wireless Press, Inc., 25 Elm Street, New York City.

* * *

J. C. W., New Orleans, La., inquires:

Ques.—(1) Is it not a fact that by careful design of an induction coil the amateur could obtain better results than by accepting whatever design the manufacturer happens to present to him?

Ans.—(1) There is no doubt that if spark coils are to be used for direct excitation of a wireless telegraph aerial careful consideration of the design of the secondary is highly important. For instance, the voltage should not be too high nor too low, and the current output should be such that there will be no arcing at the spark gap, but a clear, clean-cut spark discharge. With small aerials, a coil of high voltage is required, but with large aerials a lesser voltage may be employed. The aerial of large capacity will, of course, require a coil with a greater secondary current output. If the induction coil is employed to excite the condenser of the closed oscillation circuit then there would be an advantage in designing the secondary to permit the use of a rather large capacity. Care must be taken, however, that the capacity of this condenser is not too great for the wave-length to be employed, i. e., in the case of the 200-meter wave it should not exceed .008 microfarad.

Ques.—(2) Will you please mention the name of a book devoted particularly to the construction of induction coils?

Ans.—(2) The book entitled "The Design and Construction of Induction Coils," by A. F. Collins, can be obtained through the book department of The Wireless Age.

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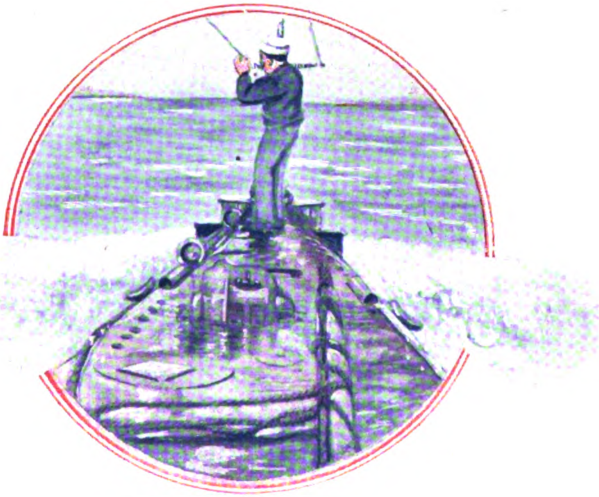

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WORLD WIDE WIRELESS

German Station in South America No Myth

THE new disclosures made public by Secretary Lansing concerning Prussian trickery and intrigue in Argentina will not surprise anyone. Prussian methods could not be made blacker than they have already been proved to be. The new information merely constitutes additional evidence of the gigantic German conspiracy against the rest of the world. The total is complete and damning.

A little note in the Luxburg correspondence indicates that the German agent in Buenos Aires, in pursuance of orders from Berlin, actually erected a wireless station with a view to communicating directly with the wireless operators at Nauen, on German soil.

Buenos Aires is 7,000 miles from Nauen. It would be highly interesting to know whether such communication ever was established, and if so to what degree it was efficient.

Under date of July 20 Luxburg wired to Berlin:

"Receiving plant erected according to instructions. When does Nauen send at greatest strength, and which is the wave length?"

This means that a German radio plant had been erected in Argentina and that Luxburg wanted to know when the great German sending radio plant at Nauen sent and what were the wave lengths the Nauen station was using, so that the messages might be picked up in Argentina.

In the same message Luxburg shows that he had plenty of money for German propagandist and other operations at his command. He makes the statement to his home Government that his legation had 856,000 pesos in bank at Buenos Aires. Less than a month later there appears to have arisen some question regarding the radio concession and the transocean wireless service, for on August 16, in reply to a message from Berlin, Luxburg sent this significant message:

"Readjustment probable, not certain. Objections of Government regarding concessions have to be overcome. What amount is to be reimbursed to Transocean? What is desired is that the German Government as sleeping partner should share expenses up to date, half and half, with Siemens Schuckert, and also in future the working expenses of the company."

The Siemens Schuckert companies evidently are alluded to in this message. The Trading With the Enemy list issued by the United States Government on December 5, giving the names of enemy firms in South America with which Americans are forbidden to trade, included the "Siemens Schuckert Companies, Buenos Aires."

The word "Siemens" in the above Luxburg telegram was a sufficient cue to the American Government when it came into possession of this message. Officials recalled the connection of the Siemens interests with the German

radio station at Sayville. It was the Atlantic Communication Company that asked for the license for the operation of the Sayville radio station. The license was refused, partly because the Atlantic Communication Company was owned by the Telefunken Company of Germany which is itself owned by the Siemens & Halske Company and the Allegemeine Electricirate Gesellschaft of Germany.

Marconi to Be High Commissioner to United States

ALTHOUGH no information is available either from Italian official sources or the State Department regarding the appointment of Mr. Marconi as Italian High Commissioner to the United States, it is assumed that he will come to this country in the same capacity as other High Commissioners named since the war to co-ordinate all of the war activities of his Government in the United States and arrange a closer co-operation with the American Government. His duties here will probably be similar to those of Lord Northcliffe for the British Government.

Senatore Guglielmo Marconi, who has been appointed head of the Italian Permanent Mission in America, made the following remarks in addressing the Senate on Italo-American relations:—

"The Italian mission to the United States again realized during its journey the great friendship and sympathy existing there for us and the great assistance the United States is ready to give us.

"The friendly feeling and concrete measures adopted by the American people in favor of Italy deserve our entire gratitude. We must consider the spontaneous American intervention in the war with special satisfaction."

Senatore Marconi was a member of the Italian mission which came to the United States last spring. After his return he served on the staff of General Piaz, the Italian commander in chief, with the rank of commander, giving special attention to the wireless system at the front.

Historical Brant Rock Station Demolished

A FIRM of contractors has bought the 420-foot wireless tower at Brant Rock, Mass., a familiar sight to Worcester summer visitors, and converted it into junk. The only signal tower like it in the world is on the north coast of Scotland.

The station cost the International Signal Company $1,000,000 to build, it being the first erected on the Atlantic coast, at which early experiments on the 500-cycle transmission apparatus were made, in the United States.

The tower was cylindrical in shape and supported by wire cable stays. The plant made 60 tons of scrap iron and steel, including the cylindrical standard and the wire cables.

President's Master Message Speeded by Wireless

THE record of two extraordinary circumstances will go down to posterity with President Wilson's masterly message giving the aims and basis for world peace. The first circumstance is the manner in which it was distributed throughout the reading world; second, the remarkably short time—one hour and forty-five minutes—it took to spread it broadcast.

A full half hour before the President's message was flashed to all the ends of the earth—to every point in Europe, Asia, Africa, Australasia, South and North America, every island in the Atlantic, Pacific and Indian Oceans, possessing a telegraph or wireless instruments, newspaper or courier service —word had gone out to "clear the way for an important address by President Wilson."

The mighty naval radio stations at the Brooklyn, San Diego and Darien were primed to play their part. Shortly after Darien, which is on the Isthmus of Panama flashed the word to the Pacific, Atlantic and Indian Ocean islands that something big was coming and to lend an ear, the operator at Heligoland, it is believed by naval officials, became immediately attentive. There was extraordinary power and punch in the Darien operator's key, and it is fair to assume the Prussian operators at the Hamburg, Kiel, Berlin, Karlsruhe, Frankfort, Prague, Vienna, Constantinople and Philoppopolis radio stations were brought to a sharp state of wakefulness.

Promptly at 12:30 o'clock, New York time, the director of the Division of the Foreign Press Service of the Committee of Public Information, signaled the cable companies and the naval radio station at Brooklyn to begin sending the President's message.

Until the message was fully transmitted seven men in the room were kept under lock and key. Advance word on the message would have been of tremendous importance in Wall Street.

The message from Washington came over the Government's private wire. After it was received it was read back to Washington by telephone to make sure that every word was correct.

The seven men in the room were the Director, his assistant, two naval officers, two operators and a stenographer. When the message was verified by Washington it was split into "cable takes" of about 100 words each, and the operators started their work. The message contained about 2,700 words.

American Marconi Company's Profitable Year

GROSS earnings of the Marconi Wireless Telegraph of America have nearly doubled during the period of the war, while expenses, including taxes, were less last year than in 1914. The company's net income for 1917 was $609,430, and undivided profits and reserves on December 31, last, amounted to $2,150,000. The capital stock is $10,000,000.

A comparative summary of receipts and expenses follows:

	1914	1915	1916	1917
Gross earnings	$756,572.75	$748,238.03	$862,501.55	$1,328,525.94
Deduct: Total expenses including estimated taxes	634,958.25	564,176.34	624,568.94	576,038.30
Net earnings from operations	$121,614.50	$184,061.69	$237,932.61	$752,487.64
Income from investment of surplus funds	150,274.21	104,932.97	98,107.98	97,442.86
	$271,888.71	$288,994.66	$336,040.59	$849,930.50
Deduct: Reserves for depreciation	122,011.24	111,678.15	76,151.79	240,500.00
Net income for year after charging reserves	$149,877.47	$177,316.51	$259,888.80	$609,430.50

Capital stock	$10,000,000.00
Undivided profits and reserves, December 31, 1917	2,150,000.00

These figures have been published by authority of the Directors as a statement preliminary to that to be issued prior to the Annual Meeting which will be held April 15, 1918.

Description of "Zep" Apparatus Given by Crew

SOME of the aerial secrets of the Kaiser's Zeppelins revealed by the capture intact of the L-49 at Bourbonne les Bains in France have now reached this country. The French censor did not permit detailed or technical descriptions of the giant raider to reach the press, but British and American expert observers were invited by M. Dumesnil, French under secretary for

aviation, to examine the German craft, and through English sources some of the secrets of construction which they learned are now reaching the ears of American experts.

Perhaps the most interesting fact about the L-49 is the extent of its wireless equipment. The wireless installation is extremely highly developed. It is of the Telefunken type, capable of sending wave lengths of from 1,000 to more than 5,000 meters. The antenna, 400 feet long, is suspended from the craft.

Announcement has been made of what is known as the scheme of Zeppelin guidance from Germany. Before the war, as is known, Germany was literally dotted with high powered wireless stations. By a suitable reciprocal arrangement of the wireless apparatus of the L-49 and that of the other German raiders and of the chief of the high powered wireless stations in Germany, it is possible for the latter, according to the crew of the L-49, to tell within a very small margin of error the exact direction from which a Zep-sent message is received. A message from the L-49, for instance, would be simultaneously received by two widely separated high powered stations in Germany. These latter stations would then get in wireless communication themselves, and, by a simple computing of distance by angles, determine almost the precise location of the signaling Zep. This position, in terms of latitude and longitude, one of the stations then would wireless back to the operator on the L-49, who could thus direct a course regardless of fog or height or any uncertainty from breakage of instruments or weather obscurity.

In all probability, this so-called description of wireless guidance, given by the crew, is a distortion of the more probable use of the radio goniometer, or direction finder, which incidentally, appears to be playing an important role in the war.

Germany's Attempt to Establish a Station in Mexico

AGENTS of the German government attempted to establish a wireless telegraph station on the west coast of Mexico in 1914, according to testimony given in San Francisco on January 4th, at the trial of thirty-one persons charged with conspiracy in connection with a proposed revolution against British rule in India.

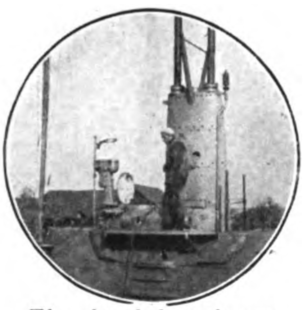
Gustave Koeppel, a shipping broker of San Diego, Cal., on the stand in the United States District Court, said he had arranged several details in the wireless matter for Baron E. von Schack, former Vice-Consul General for Germany in San Francisco. The plan failed, Koeppel said, when several persons engaged in the enterprise had been arrested by Mexican authorities, and the expedition returned to the United States.

A Cantonment With a Wireless Fire Alarm

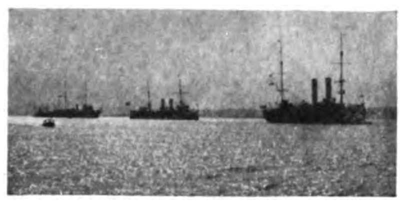
A WIRELESS fire alarm system has been installed at Camp Dix, Wrightstown, N. J., to protect the ten great storehouses where provisions and equipment for the entire cantonment are kept. It brings to the highest state of efficiency the system perfected by Lieut. John J. Sweeney, chief of the camp fire department, for the protection of the 2,200 buildings of the camp against damage by flames.

The system bids defiance to sleet and wind storms that destroy telephone lines and other means of communication. Thermostats in different parts of each building connect with a wireless sending outfit, which will automatically flash a fire signal to the headquarters of the 303d Signal Battalion. The operator on duty day and night can tell at a glance the building from which the signal comes. He will immediately relay the alarm and definite information as to the location of the blaze to fire headquarters.

Under the Sea in a Submarine



The dreaded periscope



Down the river in the cold gray of the morning

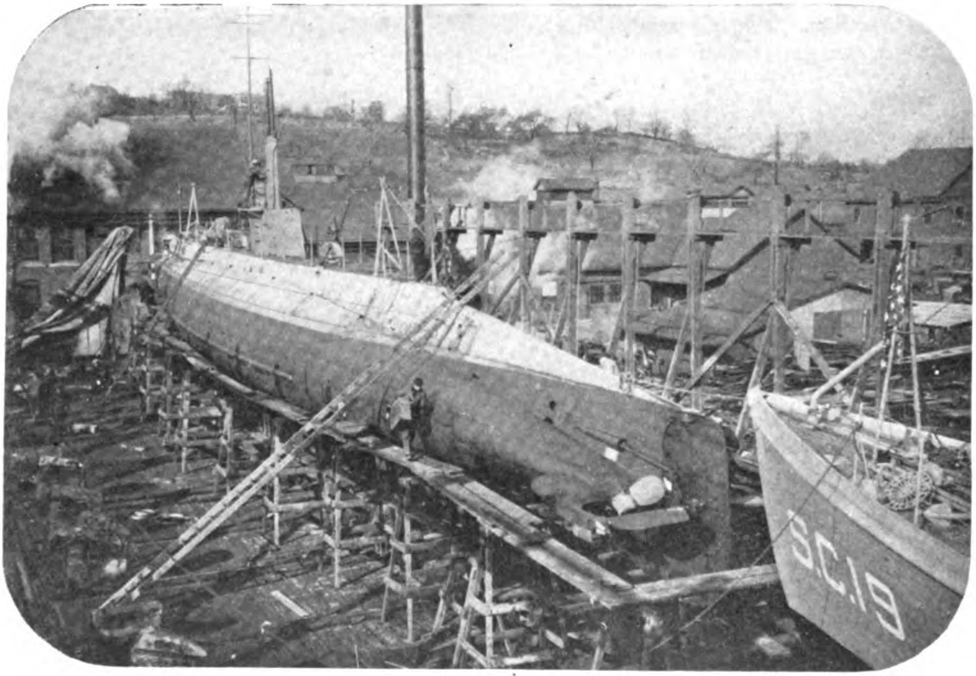
Speeding on the surface

By P. B. COLLISON

THE WIRELESS AGE has previously chronicled many hair-raising tales of encounters with submarines. In these accounts the "sub" was given the villain's role and little mention was made of the marvelous devices which make its capture so difficult. I recently spent two months aboard a fleet of six of these "mechanical fish," during which I went on several trial trips. In this article I have described the "sub's" working parts.

A trip under the surface of the water is an event to be long remembered. We started down the river in the cold gray of the morning with a fast patrol boat just ahead of us to keep our course clear when we were running submerged. Out past the forts into the open sea we sped, the boat throwing up a large bow wave, the spray of which blew back and whipped across our faces like an icy lash. Soon the order was given to prepare to "dive," and I entered the conning tower with the Captain. First, all railings, the wireless masts and aerials came down, the latter being stored in the forward hatch. The crew then went below and made the hatch fast and watertight. In a similar manner all other openings were quickly closed, and after a rapid inspection by the Captain we were ready to enter the domain of the fish. Sufficient water was then taken into our ballast tanks to neutralize the buoyancy of the hull.

To look out through the tiny glass ports of the conning tower and see the ocean rise and cover your decks is no pastime for a man with a weak heart. Gradually the water rises over the ports and you are in a world of green. You can see only a few feet ahead, really not more than ten. Unless in very clear water you can never see your own bow, contrary to various published statements; neither do the fish come up and smile at you through the glass. When one of these underwater craft enters their world the fish swim away. The ballast tanks were divided into enough compartments to allow the balancing of the boat because, if not exactly balanced, the craft would stand on end and sink down into



The particular boats which I surveyed are nearly two hundred feet long, blunt nosed, with a long tapering tail. From a birdseye view they resemble huge fish

the mud. We submerged to about fifteen feet below the surface and then set our periscope to look dead ahead. Off to one side we could see the patrol with her men peering at us with glasses. Dead ahead was the open sea. On the other side was a tug towing in a string of heavily laden barges. Overhead a gradually brightening sky smiled down on us, and about us was the peaceful calm of the depths.

Given the order to proceed ahead, we continued on our course. The electric motors gave little if any vibration to the hull. We slipped along through an unchanging green for quite a while and then the Captain asked me if I had looked up yet. Having been trying to pierce a solid wall of water with little success I wondered what I could see by looking up rather than ahead. Such a sight! The under-surface of the water appeared as a stormy sky across which were scurrying flashing patches of brightness. These phenomena were caused by the reflection of the sun on the waves at the surface and our own speed.

Looking through the periscope we saw a flock of wild ducks, frightened by those queer glass eyes rushing at them, jump from the surface of the water, and far ahead another pair of periscopes coming towards us almost hidden in a smother of foam. I then went below and using the "oscillator" tried to find out something about the approaching craft, but without success. However, in the course of a few minutes I learned that there was an "old Marconi Op" at the key.

We altered our course to clear the other boat and then dove deep down. The Captain told me to keep a sharp lookout ahead as we were going to "porpoise" —whatever that might be. Next I realized that we were rushing to the surface at an angle of about thirty-five degrees from the horizontal. Looking ahead I saw the sea change to a lighter green and, as our tower started to emerge from the sea, a rushing of water was heard. Suddenly the green became white and then the sun broke into view. Immediately afterward we beheld our own bow rising up out of the water and we were again able to look around over a sparkling

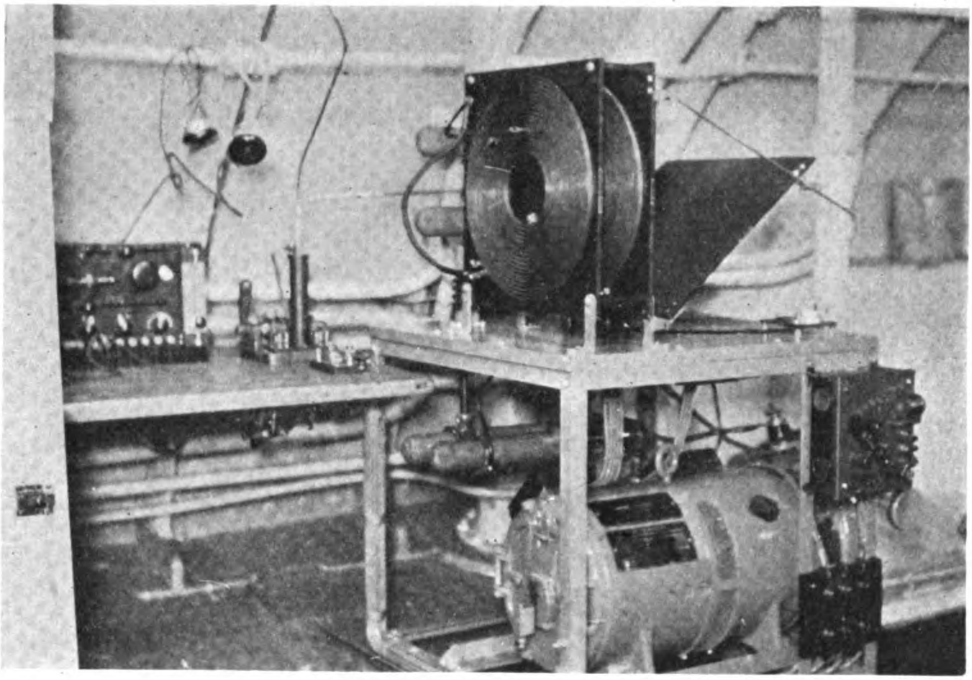
blue sea; but only for an instant. The bow again sank into a creamy foam and we observed a white crested wave rushing back at us. Instinctively we recoiled, believing that we were about to get wet, but of course the glass kept the water out. There came another rush and roar of water, the scene changed to the white foam of the water and then back to a beautiful pale green, and the silence of the depths was about us once more. We again proceeded quietly and shortly afterward came to the surface once more to show the patrol where we were and to shift our course into deeper water. Our ballast tanks still being full we did not open any of the hatches.

Ordinarily, when a submersible wishes to come to the surface the water is driven from the tanks by powerful pumps. This takes a few minutes. However, the Captain on this trip desired to make a test of the emergency depth gauge. The hull is only made to withstand certain pressures and since the pressure rapidly increases as you sink deeper it is necessary to have some method of quickly bringing the boat to the surface, should the horizontal rudders refuse to bring the craft up. They therefore carry several air flasks filled with air under terrific pressure to blow the water from the tanks. This causes the vessel to rise at once. These valves can be set to open at any depth. Our valves were set for a trifle less than 100 feet and we dove down past the danger point. With a rush and a roar the water was forced from the tanks and we were literally blown out of the water in a smother of foam and spray.

After opening the hatches we started the Diesel engines and proceeded on the surface back to the base. All hands made a rush for the open air as it was getting thick inside. But it was necessary to exercise caution, for the fresh air acts as an intoxicant and one is liable to become violently seasick or dizzy or both. The decks being still wet and very slippery, there is danger of falling into the water, which might result in being ground to pieces by the propellers.

The wireless mast and deck insulator are just at the point of the shears

All railings, the wireless masts and aerials came down before we submerged



The compartment which contains the wireless apparatus, also holds the underwater signaling diaphragms; the wireless operator is in charge of both

Because of the publicity given to its piratical activities, the outside of a submarine is familiar enough to all. I will therefore dwell lightly on these features. The particular boats which I surveyed are nearly two hundred feet long, blunt nosed, with a long tapering tail. From a birdseye view they resemble huge fish. Along the backbone is placed a light, flat superstructure or deck containing four small circular hatches which are surrounded by a light bronze cable supported by detachable stanchions. There is also a long slanting hatchway through which the torpedoes are lowered into the hull. A collapsible crane is provided to swing these long, slender, miniature submarines aboard, for they weigh close to a ton and sometimes more.

The next point of interest is the conning tower, from which protrude the antenna-like periscopes. The latter are protected and supported for a part of their height by curved, flat plates called shears. These shears are made in a streamlike form to lessen head resistance when the boat is running submerged. The conning tower with its tiny glass ports is placed just forward of the periscopes and likewise is protected by shears. A small "bridge" encircles the top of the tower and on this are mounted an engine room telegraph, electric steering gear control, and gyro-compass repeater. These are placed in a small watertight case supported on a pillar much like an ordinary compass stand except that it is made entirely of metal. When the boat is operating beneath the surface a watertight lid is screwed down over these controls. All movements of the boat on the surface are controlled from this point.

The wireless mast and deck insulator are located just at the point of the shears for the radio equipment. A very heavy electrose insulator set on the top of a heavy brass pipe with another electrose insulator placed at the bottom brings the lead-in wires to the apparatus. The wireless masts (of which there are two) are hinged at the deck and are lowered and "lashed fast" when the order is given to prepare for a "dive." The rear portion of the hull superstructure con-

tains the engine room hatch and then the hull tapers off to the tail which supports two screw propellers and the vertical and horizontal rudders.

So much for the general appearance externally. We will now enter the hull through the hatchway nearest the bow. This hatchway is only eighteen inches in diameter. Upon entering the hull you must keep your head down and your eyes wide open. The deck space being rather limited all machinery possible is hung from the shell overhead, leaving scant headroom. I can truthfully state that "my first impression upon entering a submarine" was a dent caused by unexpected contact with an anchor windlass motor. This was fastened on a level with my face just back of the entrance ladder. One lesson was enough; on every occasion afterward when I came down that ladder I "ducked."

The first to meet the eye upon entrance are the "stingers" or torpedo tubes of which this boat was equipped with four, two above and two below. Water is prevented from entering the hull, when the breech plates are opened to place a torpedo in the tube, by an outside swinging bow cap. The procedure is to close the bow cap, then drain the tube, and by means of a small traveling crane place the torpedo in the tube. The bow cap is then turned and air, at a pressure of 2,800 pounds to the square inch, is admitted behind the torpedo. This drives the torpedo out with a rush and as it leaves the tube a small trigger is forced back which sets its tiny compressed air turbines into motion.

The torpedo will go forward until the air pressure no longer will drive the turbines. If it has missed its mark its sea-cocks are set so it will sink. Otherwise it would float about on the surface, a menace to friend and foe alike. Each of these vessels were supplied with eight torpedoes, four in the tubes and four on racks inside the hull. The space underneath the floor of this forward compartment is taken up by ballast tanks, fuel tanks, room for several air flasks, and a storage battery well. The fuel tanks hold more than 5,000 gallons of oil and the forward battery compartment holds sixty 3,500 ampere-hour storage cells. The sides of the shell give space for the lockers which contain the bedding and personal effects of the crew. The men sleep on cots when the weather is good, but in bad weather they sleep in hammocks swung from the shell overhead.

This compartment also contains the wireless apparatus and the underwater signaling apparatus. The latter device consists of two large, thick diaphragms set one on each side of the bow. The diaphragms are set into oscillation by solenoids through which pass a 500-cycle alternating current of about five kilowatts. The sound waves sent through the water travel up to forty miles or more, depending on the depth and density of the water through which they travel. The deeper the boat is submerged, the farther it can signal. A regular telegraph key is used and by means of the Continental Morse or any other code communication is carried on in a manner similar to radio. The wireless operator is in charge of the underwater system as well as the radio apparatus.

Through a watertight bulkhead, we next enter the "brains" of the boat. This part of the interior, known as the central operating compartment, contains a staggering number of air and water gauges and valves which control the buoyancy of the hull. One of the largest dials shows the depth at which you are operating. It runs up to 200 feet. There are also large brass wheels controlling the horizontal or diving rudders and the vertical rudder. Another gyro-compass repeater is fastened on the bulkhead in front of the helmsman. A small ladder leads up into the conning tower which is separated from the main hull by a small watertight hatch. This can be closed from beneath in case the conning tower is damaged by shell fire. Up here we see more gauges and appliances, also one of the periscopes. We look into an eyepiece much similar to a telescope and by means of large control handles the barrel can be swung around so as to view any portion of the horizon. Objects appear exactly as they do when viewed through a telescope.

The helmsman stands directly under the conning tower and steers under direction from the Captain, who, when the vessel is submerged, is always stationed

at the periscope. Another larger periscope with an eyepiece in the operating chamber is used also to take observations because the upper one is usually pointed dead ahead, although it can be swung around to any angle. Besides the helmsman, men are stationed at the diving rudders and "Kingston" valves which open from the ballast tanks into the sea. Other men operate the pumps. In fact, every individual in the boat has a definite task and is highly trained to do just this and nothing else.

The electrical compartment contains the master Gyro-compass. The "master" compass is carefully installed in a safe place and being non-magnetic can be placed without regard to outside disturbing forces. Electrically operated relay "repeaters" are distributed throughout the vessel. These repeaters operate in any position and are connected to the master by a flexible armored cable which permits their being moved about if necessary. Here, also, is the electric stove with its grills and ovens. Food lockers and a sink fill one corner. At the rear of the compartment are the switchboards, controlling the charge and discharge of the main storage battery. Underneath the floor is a second set of sixty storage cells.

Two immense Diesel oil engines and the two generators are in the engine room. The oil engines propel the vessel when operating on the surface and at the same time drive the two electric generators which charge the battery. When operating under the surface the engines are stopped and the dynamos, connected as motors, drive the vessel at a slightly reduced speed. For slow speed the storage battery banks are connected in parallel giving a potential of about 120 volts; for full speed the banks are connected in series giving 240 volts. The battery is thus discharged evenly.

The battery is ventilated when charging on the surface by means of motor driven blowers which drive the gases out into the air. When under water the battery gases are blown into the hull to prevent a dangerous explosive accumulation in one compartment. After a few hours' run under water the air becomes quite warm and the gases, which are rich in sulphuric acid, condense on the cold inner walls of the hull and start to drip. It is therefore necessary for the crew to wear both water and acid proof garments.

The wireless sets on these boats give remarkable satisfaction when the handicap of a very low and short aerial is considered. Reception of signals over several hundred miles is common. Transmission is dependent on the length and height of the aerial.

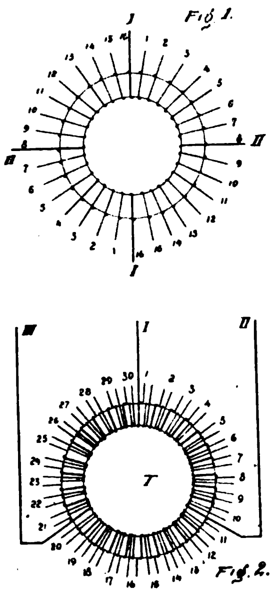
What camouflage does to a "sub"—Can you find it?

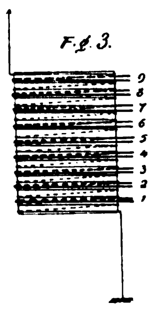
Radio Science

The Production of Continuous Waves by Spark Discharges

A SYSTEM for generating high frequency alternating currents, which is somewhat out of the ordinary, has been developed by Riccardo Arno, an Italian. By means of the arrangements shown in principle in figures 1, 2 and 3, and more in detail in figure 4, the inventor states that he is able to secure more than 30,000 spark discharges per second, resulting in a practically continuous flow of high frequency currents in a wireless aerial.

The system consists of the combination of a polyphase generator, a static phase transformer, designed to increase considerably the number of phases and





Figures 1, 2—*Arno's special static transformer*
Figure 3—*Polyphase jigger*

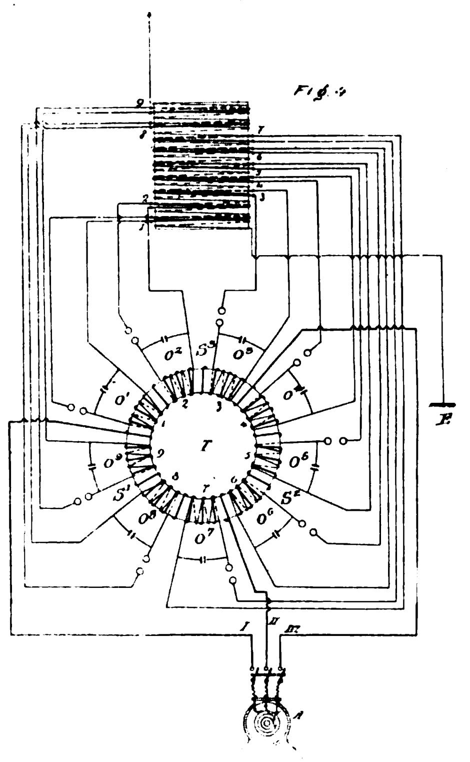


Figure 4—*A spark discharger producing continuous waves*

eventually to raise the tension of the current, and a series of spark oscillators actuated by these phases. The primary circuits of the spark oscillators are coupled to a single aerial.

Signor Arno observes that by the special static transformer shown in figures 1 and 2, he is enabled to obtain 32,000 sparks per second, provided the transformer is excited by 1,000 cycle alternating current and is constructed to give 16 phases of current.

The construction of the transformer is as follows: A torus of magnetic material carries a continuous winding. At equidistant points it is fed by a polyphase current. In the figure the feeding current is biphase. The phase of the difference of potential between two diametrically opposed convolutions, varies with the angles formed by this diameter with the diameters I, I and II, II. In the case of the figure, for example, the phase of the difference of potential between the points 4, 4, differs by one-eighth of a period from the feeding phases of the difference of potential I, I and II, II. By taking a sufficient number of points on the winding any desired number of phases may be obtained. In figure 1, for example, is shown an arrangement whereby a biphase system may be changed to a 16-phase system.

Suppose n to be the frequency of the polyphase current and N, K, the total number of phases drawn from the phase transformer; the total number of sparks which can be obtained will obviously be $2n$ N K.

It is entirely possible to construct machines of 1,000 frequency. Consequently, in order to obtain 32,000 sparks per second, the phase transformer need only furnish 16 phases, and if it is desired to employ a current of the frequency ordinarily employed in the industries, 60 cycles for example, then 32,000 sparks per second could be obtained provided the phase transformer supplied 320 phases.

In practice, the phase transformer consists of several bobbins, convolutions, or windings, regularly distributed over the whole circumference. The number of these bobbins is a multiple of 4 or 3, according as the current of the polyphase system of feeding is biphase or triphase. In the first case the bobbins are placed in pairs diametrically opposed, and consequently the number of phases is equal to half the number of the bobbins.

In event that the secondary voltage must reach a certain value and the E. M. F. of the alternator is not sufficient, two courses may be followed.

First, the difference of potential of the feeding phases may be raised by means of a transformer before sending it into the phase transformer.

Second, the phase transformer may be constructed with two coils, one for the feeding phases, and the other for the secondary phases. In this case, the phase transformer operates as a transformer of potential and can serve either as a system of connected phases or a system of disconnected phases (see for example, the triphase primary arrangement I, II, III and 30-phase secondary in figure 2).

Referring to the case in which the phase transformer consists of two distinct coils, the number of phases in the secondary system may be odd or even, and it will be readily seen how, inasmuch as the generation of electromagnetic oscillations is involved, it is more advantageous to adopt an odd number of phases of the secondary system. In fact, it is clear that in the case of an even number of phases, there would be the inconvenience of having the phases in pairs corresponding to an angular value of 180°.

To utilize a large number of phases a single aerial wire can be employed as represented in figure 3, which is a polyphase jigger.

The complete arrangement is shown in figure 4, in which a triphase alternator A, of 1,000 cycles, for example, is employed; by means of three connected phases I, II and III, this alternator directly feeds the triphase primary of the phase transformer. The 9-phase secondary furnishes the 9-single phase and disconnected high tension currents to the 9 corresponding oscillating circuits connected to a single jigger 1, which is represented separately in figure 3.

The Arno apparatus is not limited to the high frequency alternator mentioned; any type of generators or oscillators heretofore employed in connection with the wireless art can be connected up in a similar circuit.

Open Circuit Oscillators as Receivers

IT is well known that because of the relatively high resistance of the three-electrode vacuum valve it requires to be connected in a receiving circuit which will impress the maximum possible voltage for a given group of incoming oscillations. Such a secondary circuit will give the maximum strength of signals.

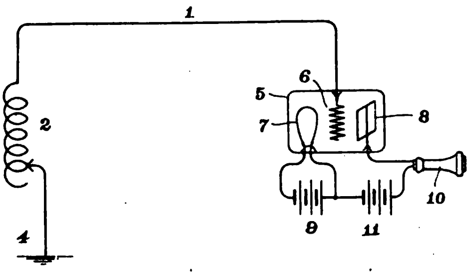


Figure 5—*Bucher's valve detector circuit*

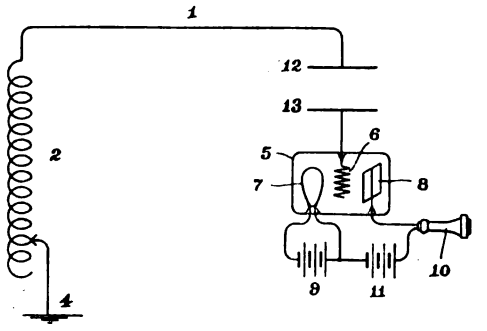


Figure 6—*Circuit with alternative arrangement*

An unusual detector circuit, shown diagrammatically in figures 5 and 6, is credited to Elmer E. Bucher. In both diagrams the three-electrode vacuum valve detector is connected to the free end of the wireless telegraph aerial, and at the opposite, or earth end, a tuning coil is inserted to tune the aerial circuit to resonance or impress the maximum potential on the grid of the vacuum valve for a given group of incoming oscillations. An alternative arrangement is shown in figure 6, where the grid of the valve is electrostatically coupled to the free end of the wireless telegraph aerial.

As in the usual wireless telegraph receiving circuits, the aerials of figures 5 and 6 may be tuned to resonance by variable condensers as well as by radio-frequency inductances.

Electron-Discharge Apparatus

STUDENTS of radio engineering who have followed the development of the pure electron-discharge apparatus will be interested in the perfection of a new vacuum tube by Dr. Irving Langmuir.

The filament of his new tube consists in part of thorium, which at a given temperature has a much greater electron emission per unit surface than the emission of a refractory metal such as tungsten. In the preparation of these tubes, great care must be exercised to remove the last traces of oxygenous gases, particularly water vapor, and the precaution must be observed not to evolve water vapor from the bulb walls during the operation of the device.

The tube shown in the drawing, figure 7, may be employed to rectify alternating current. It comprises an envelop 1, consisting of a glass not chemically attacked by alkali metal, provided with a cathode 2, consisting for example of thoriated tungsten, and a cylindrical or cup-shaped anode 3, also consisting of a highly refractory metal, such for example, as tungsten.

The cathode 2 is prepared by adding a thoria compound, such as nitrate of thorium to the oxide of tungsten before reduction of the metal, or by adding either thorium nitrate or thoria to the metal powder after reduction.

The preliminary evacuation of the envelop is carried out by the usual methods of producing a non-striking high vacuum, which includes baking out the envelop to remove water vapor. The final stage of the evacuation is preferably, but not necessarily, carried out by a Gaede molecular pump to the highest possible vacuum obtainable by this means, that is, to about .001 micron. While the apparatus is still on the pump the cathode 2 is heated to a temperature of about

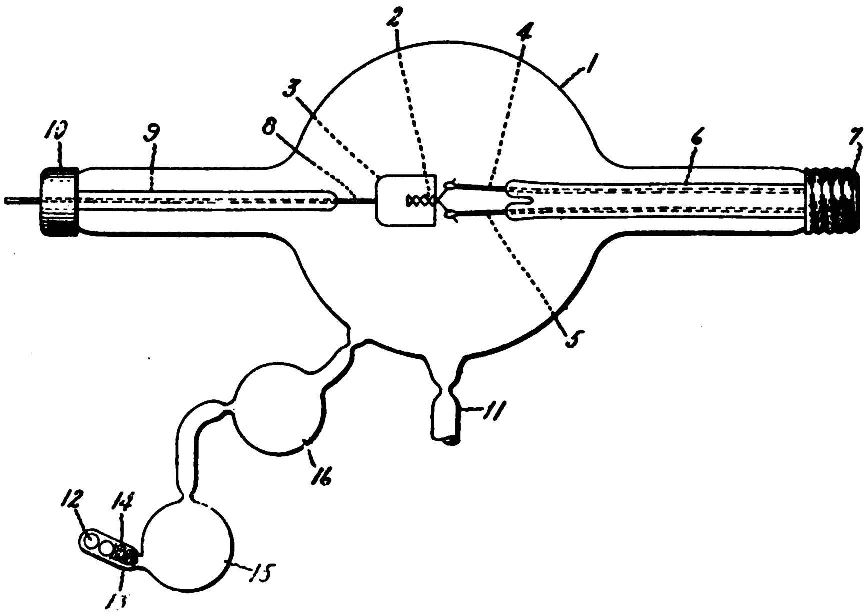


Figure 7—Langmuir's vacuum tube for electron-discharge

2900° K. (2727°C.) for a short time and the envelop 1 is baked out in an oven at a temperature of about 360 to 450°C.

The substance to be distilled into the envelop, for example, potassium, is indicated at 12 in a small side chamber 13, a small quantity of glass particles, or glass wool, 14, being preferably placed in front of the reducing material. As already indicated all glasses (including the glass wool) used in the apparatus should be unattacked by alkali metal. When the envelop is baked out care should be exercised not to heat the chamber 13 to too high a temperature. The potassium, or other material, is transferred by melting into a communicating chamber 15, after which the chamber 13 may be sealed off. Thereupon, the material is distilled into a second communicating chamber 16 and finally a very small amount is introduced into the main envelop 1, both the chambers 15, 16, being successively sealed off. The redistillation of the reducing material serves to purify it. Although alkali metals are preferable, other reducing materials may be used, for example, hydrocarbon compounds. The bulb is finally sealed from the vacuum system at the contraction 11.

The thoriated cathode 2 is now heated to about 2900° K. for about one minute. The treatment of the filament at this temperature appears to be desirable for purifying the surface of the cathode. The cathode is then incandesced within the range of about 2000° to 2400° K, and by this temperature treatment some change is produced in the cathode which enormously increases its electron-emitting property under the condition described. The greatest activity is obtained between about 2200° to 2300° K. and the treatment at this temperature is usually continued for about one minute. Apparently a concentration of metallic thorium or of some other oxidizable thorium material takes place on the surface of the filament. The filament 2 may now be used as a cathode at or below this forming temperature.

Under carefully controlled conditions the benefit of the increased electron emission of a thorium-containing cathode may be secured in a device filled with an inert gas, such, for example, as argon or other monatomic gases, at pressures ranging from a few millimeters of mercury pressure upward, in the presence of potassium or equivalent material for preventing the oxidation of thorium. Care

must be exercised to have the cathode at a high enough temperature with reference to the current transmitted so that the vicinity of the cathode is surrounded by free electrons. In other words, the electron emission should be greater than necessary to convey the current thereby preventing a removal of the active thorium material on the surface of the cathode by a bombardment of positive ions.

With the filament thus prepared Dr. Langmuir has obtained at a temperature of about 1300° to 1380° K. substantially the same electron emission per square centimeter as with a pure tungsten filament of about 2000° K., that is, about 3 miliamperes per square centimeter. A thoriated cathode may be operated around 1700° to 1800° K. at which temperatures its life is long, and thermionic current may be obtained many thousands of times greater than obtainable with pure tungsten at the same temperature.

A Recent Development in Wireless Telephony

THE vacuum tube lends itself to a variety of uses in the art of wireless telephony. It may, for example, be employed as a generator of radio frequency current, as an amplifier of the output of a radiofrequency alternator, or as a modulator of radiofrequency current in accordance with the fluctuations of the human voice.

In the majority of wireless telephone systems heretofore described, the apparatus has been of the type in which a portion of the high frequency current was constantly radiated by the wireless telegraph aerial and this current was modulated by a superposed current of mean speech frequency. John R. Carson has recently designed a wireless telephone transmitter, the important feature of which is that the wireless aerial radiates no energy until the microphone transmitter is spoken into.

Carson's circuits are shown in the accompanying drawings, figures 8 and 9. In figure 9, telephonic signal waves are generated by the variations of a transmitter 1, in a circuit 2, containing a source of direct current 3, and a winding 4 of a repeat coil 5. A second winding 6 of the repeat coil, is connected to the input side of an amplifier 7, the output circuit of which, 8, contains a second winding 9 of the repeat coil 10. A second winding 11 of repeat coil 10 is a part of circuit 12, which includes also a condenser 13 and the field winding 14 of a high frequency alternating current generator 15.

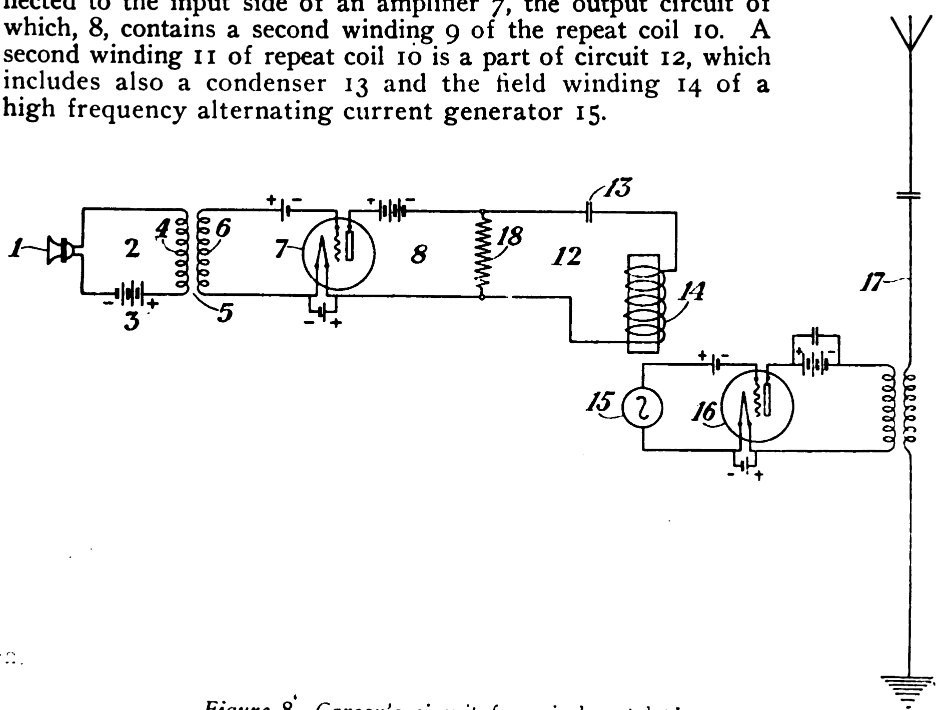


Figure 8—Carson's circuit for wireless telephony

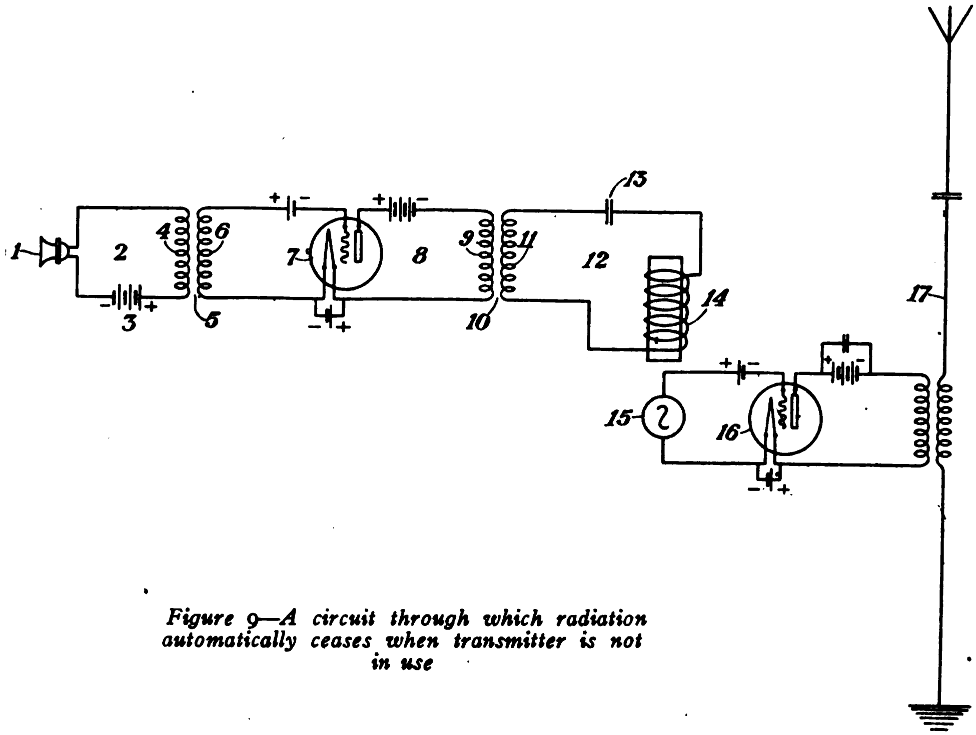


Figure 9—A circuit through which radiation automatically ceases when transmitter is not in use

Coupled to the armature of the high frequency generator is a high frequency vacuum tube amplifier 16, the output circuit of which is coupled to a wireless telegraph aerial. Several amplifiers may be connected in parallel at this point if desired.

Because the circuit 12, including the field winding 14, is inductively coupled through amplifier 7 to a transmitter 1, it will be self-evident that alternating current alone flows in the field windings of the generator; that is, there is no direct current component in the field winding 14, which is an important development.

Because alternating current flows in the field winding of the generator only when the transmitter 1 is spoken into, it will be seen that the high frequency currents which set the antenna circuit into oscillation are generated only when the transmitter is actuated.

When the transmitter 1 is in operation, telephonic current flows in circuit 2, and by means of a repeat coil 6 an alternating voltage of signaling or telephonic frequency is impressed upon the amplifier 7. A current, the reproduction of the signaling current, therefore flows in the circuits 8 and 12. By means of a condenser 13, circuit 12 may be tuned to offer a low impedance to the signaling frequency.

As a consequence, a high frequency wave is radiated from the antenna 17, the amplitude of which is directly proportional to the low frequency signal wave.

The important advantages gained by this system will be readily appreciated by those who understand the problems of wireless telephony. In ordinary radiophone systems, there is a continuous radiation of energy in the form of an unmodulated carrier wave, even when the transmitter is not spoken into. The transmission of this unmodulated wave, besides involving a waste of energy, constitutes a serious bar against the operation of duplex systems. But with the arrangements just described, energy transmission or radiation automatically ceases when the transmitter is not in use.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

ARTICLE IV

CHAPTER III (Continued)

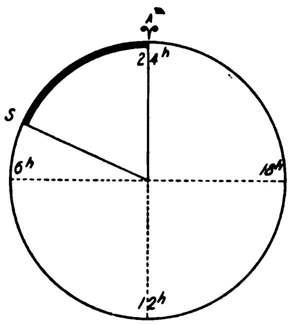


Figure 24

Right Ascension

THE right ascension of a celestial body is the angle at the pole between the hour circle of the body and that of the first point of Aries. It is measured from the first point of Aries eastward, extending up to 360° or twenty-four hours.

P is the pole.

A is the first point of Aries.

A S is the right ascension of S. (Figure 24.)

Sidereal Time

Sidereal time is the hour angle of the first point of Aries. This point, which is identical with the vernal equinox, is the origin of all co-ordinates and does not, like the sun, moon and planets, have actual or apparent motion therein. It shares in this respect the properties of the fixed stars. We may therefore say that intervals of sidereal time are measured by the stars.

The Apparent Sun

The apparent sun is the real visible sun. Its apparent movement in the ecliptic is irregular, rendering days of unequal length.

The Mean Sun

An imaginary sun is supposed to move in the equinoctial with a uniform velocity equal to the mean velocity of the true Sun in the ecliptic. This mean sun is supposed to coincide with the true sun at the vernal Equinox or the first point of Aries.

Apparent Time

Apparent time or solar time is the hour angle of the center of the sun. An apparent or solar day is the interval of two successive transits of the sun. It is apparent noon when the sun's hour-circle coincides with the celestial meridian, or in other words, when the bearing of the sun is true north or true south. This is the most natural and direct measure of time, and the unit of time adopted by the navigator is the apparent solar day.

Mean Time

Mean time is the hour angle of the mean sun. A mean day is the interval between two successive transits of the mean sun over the meridian. Mean noon is the instant when the mean sun's hour angle coincides with the meridian. Mean time lapses uniformly. At certain times it agrees with the apparent time, while at times it is behind and at other times in advance of the apparent time. Ordinary clocks and chronometers for use in navigation are regulated to this time..

Equation of Time

Equation of time is the difference between mean and apparent time. The amount and application may be found in the Nautical Almanac for any given day.

Civil Time

Civil time is the time used in ordinary everyday life. It begins at midnight and ends the following midnight, reckoning two periods, A. M. (ante meridiem) and P. M. (post meridiem) of twelve hours each.

Astronomical Time

Astronomical time is a continuous period of twenty-four hours, beginning at noon and ending at noon the following day.

The Celestial Poles

The extension of the poles of the earth into space, or the poles of the celestial sphere are called celestial poles.

The Elevated Poles

The pole which is above the horizon of the observer, or the pole of the earth of the same latitude as the observer, projected into the heavens is called the elevated pole.

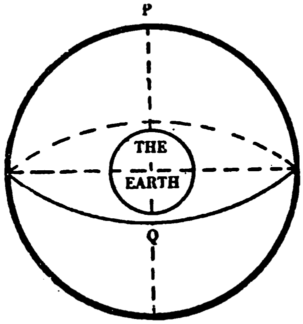


Figure 25

The Equinoctial

The equinoctial or celestial equator is the great circle formed by extending the equator of the earth until it intersects the celestial sphere. E Q E is the equinoctial.

The Ecliptic

The ecliptic is the great circle representing the path in which the sun appears to move in the celestial sphere. The plane of the ecliptic is inclined to that of the equinoctial at an angle of 23° 27½′. This inclination is called the obliquity of the ecliptic.

C C′ represents the ecliptic.

The Solstitial Points

The solstitial points or solstices are points on the ecliptic 90° from equinoxes at which the sun reaches its highest declination in each hemisphere. They are called summer or winter solstices, according to the time of the year.

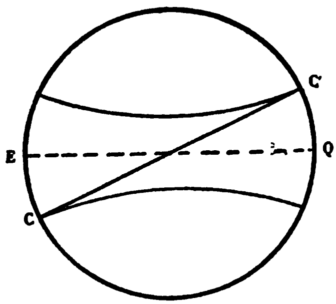


Figure 26

Celestial Latitude

Celestial latitude of any point in the heavens is its distance north or south from the ecliptic measure on a great circle at right angles thereto.

Celestial Longitude

Celestial longitude of any point in the heavens is its distance from the first point of Aries measured on the ecliptic eastward up to 360°.

Co-ordinates

A system of lines, angles or planes, or a combination of these used in determining the position of a point from some fixed plane or line adopted as a primary.

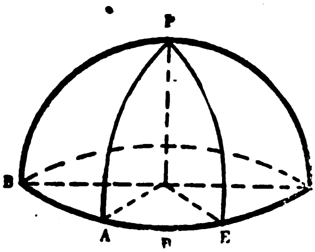


Figure 27

Hour Circles

Hour circles, declination circles, or celestial meridians are great circles of the celestial sphere passing through the poles. They are therefore at right angles to the equinoctial and may be considered formed by extension of the terrestrial meridians until they intersect the celestial sphere.

P A, P B, and P E are Hour Circles.

The Visible Horizon

The visible horizon is a small circle limiting the observer's view at sea or the intersection of sea and sky.

O is the point of observation.

H H′ H″ is the visible horizon of O.

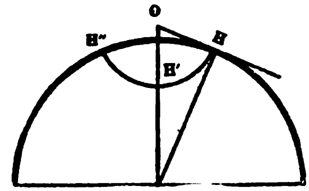


Figure 28

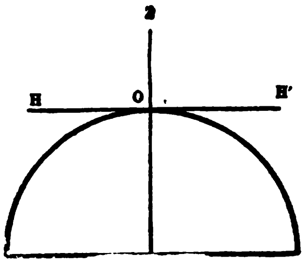


Figure 29

The Sensible Horizon

The sensible horizon is a plane at right angles to the plumb-line at the point of observation in Fig. 29. H H′ is the Sensible Horizon.

The Celestial or Rational Horizon

The celestial horizon is the great circle formed by a plane passing through the center of the earth at right angles to the zenith of the observer and extended until it intersects the celestial sphere.

H H′ in Figure 30 represents the Celestial Horizon.

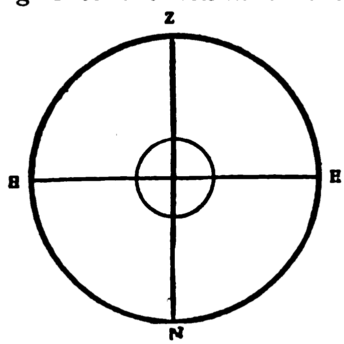


Figure 30

The Artificial Horizon

Any liquid in a state of rest forming a reflective surface is an artificial horizon, mercury being generally used for this purpose.

Dip of the Horizon

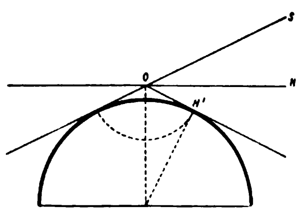


Figure 31

The dip of the sea horizon is the angle of depression at the point of observation due to the elevation of the observer's eye above the level of the sea.

In Figure 31, the angle, H O H′, is the dip of the horizon as seen from the point of observation at O.

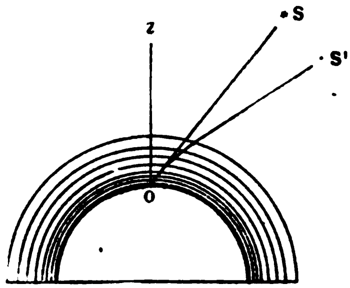


Figure 32

Refraction

Refraction is the bending of a ray of light when passing through the atmosphere. It renders the observed altitude to appear greater than its real value.

The Angle S O S′ is refraction.

Parallax

Parallax is the angle of the earth's radius at the position of the observer as seen from the center of a celestial body.

O is the position of the observer.
O C is the radius of the earth.
S is the center of the celestial body.
The angle O S C is the Parallax.

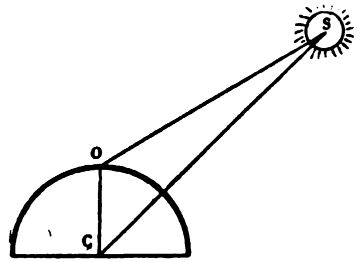


Figure 33

Semi-Diameter

Semi-diameter or half diameter is the angular measurement of the radius of a celestial object as seen from the observer's position.

The angles S O L and S O L′ are the semi-diameters of S.

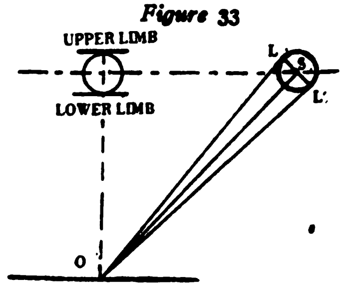


Figure 34

Augmentation of the Moon's Semi-diameter

The augmentation of the moon's semi-diameter is the apparent increase due to the decrease in distance from the observer as the moon rises above the horizon.

Observed Altitude

The observed altitude is the angular height above the horizon as measured by the sextant and expressed in degrees, minutes and seconds of arc.

The angle S O H is the observed altitude of S

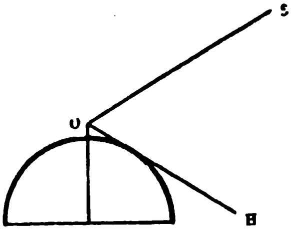


Figure 35

True Altitude

True altitude is the angular height of a point or the center of a celestial body above the rational horizon, as measured from the center of the earth.

In Figure 36, S O H is the true altitude of S.

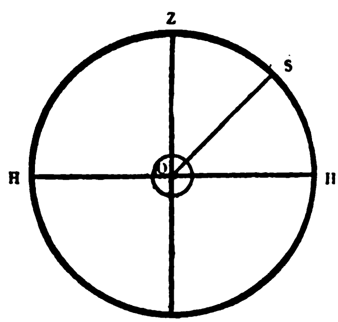


Figure 36

Zenith Distance

Zenith distance is the arc of a vertical circle between the objects and the zenith of the observer, or its true altitude subtracted from ninety degrees (90°—Alt.)

Z S or the angle Z O S is the zenith distance of S.

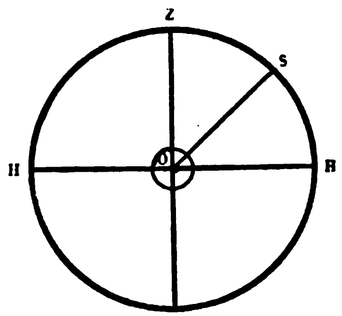


Figure 37

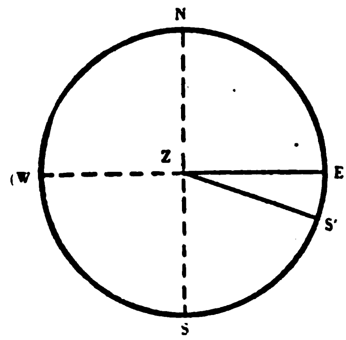


Figure 38

Amplitude

Amplitude is the angle at zenith between the prime vertical and the vertical circle passing through the center of the celestial body at the horizon while rising or setting. It is reckoned from east while rising and from west while setting toward north or south, according to the declination of the observed celestial body.

Z is the zenith.
S′ is a heavenly body.
The angle E Z S′ is the Amplitude of S′.

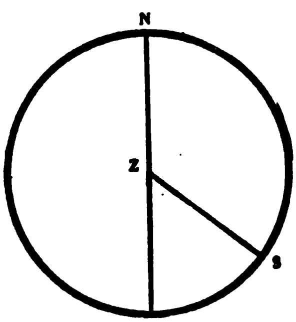


Figure 39

Azimuth

Azimuth is the angle at zenith between the meridian of the observer and the vertical circle passing through the center of the celestial body. It is generally reckoned from north in north latitude and from south in south latitude up to 180°, east or west according to whether the body is east or west of the meridian.

In Figure 39, N. S. or the angle N Z S, is the Azimuth of S.

Diurnal Motions

The movements of the celestial bodies during the 24 hours are called Diurnal or Daily Motions.

CHAPTER IV

The Compass Errors

Variation. The earth being considered as a huge spherical magnet with two poles, one is situated in about 70° north latitude and in about 97° west of Greenwich. This is called the north magnetic pole; the south magnetic pole is in latitude and longitude east of Greenwich. Thus we see that the north magnetic pole is about 1,200 miles away from the geographical or true pole. Now, a magnetic needle when suspended and allowed to swing freely in the horizontal plane, if unaffected by iron in the vicinity, will come to rest. With one end pointing to the north magnetic pole, or the direction of the needle, it will fall in with the magnetic meridian. Thus we see there will be an angular difference between the true and the magnetic meridians. This difference or error is called *variation*. It differs in amount from 0 to 180° and in name, easterly or westerly, in the different parts of the globe. We call this variation westerly if the north end of the magnetic needle is drawn or deflected to the left hand side of the true meridian, or easterly if the same end of the needle is drawn or deflected to the right hand side of the true meridian.

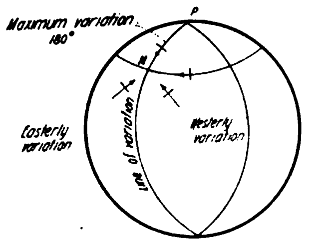


Figure 40

In Figure 40 P represents the geographical north pole and M the magnetic north pole. The arrow heads, indicating the north end of the magnetic needle, point to the magnetic pole and show the variation in different places on the globe. When correcting a magnetic course or bearing, apply westerly variation to the left hand side, or easterly variation to the right hand side in order to obtain the true course or bearing.

(Note.—Always assume that we stand in the center of the compass looking towards the circumference; otherwise right or left has no meaning in reference to variation.)

Deviation

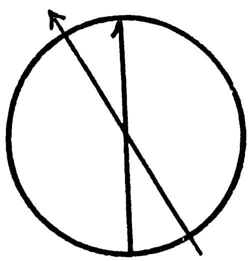


Figure 41

This is caused by the disturbing influences of iron in the construction of the ship or in her cargo. It differs in amount and name according to the direction of the ship's head or the course she is steering. When the north end of the compass needle is deflected to the left hand side of the magnetic meridian (Figure 41) the deviation is called westerly, and when the same end of the needle is deflected to the right hand side of the magnetic meridian (Figure 42) the deviation is called easterly.

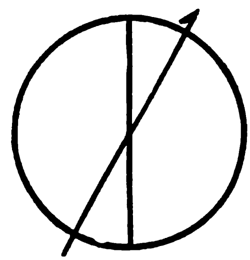


Figure 42

Rule. When correcting a compass course for deviation, apply *westerly* to the *left* and *easterly* to the *right* hand side in order to obtain the magnetic course or bearing.

(Note.—Always assume that we stand in the center of the compass looking towards the circumference, same as for Variation.)

Local Attraction

This error is caused by disturbances, such as when in shallow water, the ship passes over ground rich in iron ore. It is local and temporary in its effects, and differs constantly in its amount. It is not ordinarily taken in consideration when correcting courses.

Leeway

Leeway is caused by wind and waves pressing the ship to leeward and may be defined as the angular difference between the ship's course by compass and the actual track through the water.

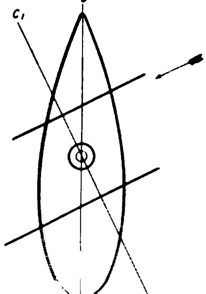


Figure 43

Figure 43 illustrates leeway. The amount differs according to strength of wind and roughness of the sea. It is best estimated when standing in the after part of the vessel and looking at the wake of the ship. The angular difference between this and an imaginary line pointing straight aft is the leeway, or in other words, the difference between the lubber line and ship's compass course.

In correcting a course for leeway, apply this when the ship is on *starboard tack* to the left or when the ship is on *port tack* to the right hand side, assuming as before that we stand in the center of the compass looking towards the circumference.

(*To be continued*)

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

EIGHTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Radio Apparatus of the Signal Corps—Part Two

Field Radio Pack Sets

The smaller size of portable sets, known as a field radio pack set, has been made in several models designated by the number of the year in which they were made. Owing to the rapid improvement in design and construction, the 1912 model has become practically obsolete.

1913 Model

Radio pack set, model 1913, consists of the following *units*:

1 operating chest.
1 hand generator.
1 mast.
1 pack frames, set (3 frames).
1 tent.

Each *unit* contains *component parts* as follows:

Operating chest:
 1 chest.
 1 resonance transformer.

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

1 condenser.
1 oscillation transformer.
1 sending key.
1 spark gap.
1 hot-wire ammeter.
1 switch.
1 receiving set.
1 connecting cord for generator (4-conductor with plugs).
1 connecting cord, with plug, for antenna.
1 double-head receiver.
1 test buzzer.
1 tool kit.
1 extra section for transformer secondary.
1 extra set crystals.
1 canvas case for receiver,
1 connector, 4-wire (lower half), generator.
2 connectors, 2-wire (lower half), antenna and counterpoise.

Hand generator:
1 generator.
2 cranks.
1 stand.
1 speedometer (carried in operating chest).
1 cap for speedometer opening.
1 canvas hood.

Mast, type F. (Type D mast has 1 top, 1 bottom, 5 intermediate, and 3 extra sections):
1 top section.
1 bottom section.
8 intermediate sections.
4 intermediate sections, extra (3 for tent).
1 antenna.
1 counterpoise.
9 carriers, wire.
4 pins, antenna.
2 hammers.
1 set adapters for tent (4 pieces).
1 bag, antenna and counterpoise.
1 bag, accessories.

Pack frames, set:
3 frames (1 set). Each frame is complete with cincha, 2 cincha straps with rings and snap hooks, and 2 straps with snap hooks at each end.

Tent:
1 tent.
14 pins.
2 guy ropes.
1 insulating device.

Complete sets should be designated as *"radio pack sets, complete,"* giving *year* and *serial number,* and should be so carried on property returns, invoices, and shipping manifests.

Operating the hand driven generator

Type F sectional mast with pack mule

Incomplete sets should not be so designated, but *units* in them which are complete should be designated as under the *unit* heading above and *units* that are not complete should be designated as under the *component part* heading. When *units* or *component parts* are used to complete sets they should be expended.

Operating chests and hand generators should always be designated by the *year* and *serial number,* and masts by the *type letters.*

Sectional Mast

The new type F sectional mast with short sections is superseding the type D with long sections as the stock of the latter becomes exhausted, as it has been found by experience that a mast with short sections can be raised more easily from the ground than one with long sections. The type F mast equipment consists of 14 sections, each 4 feet 2 inches long or 5 feet 2 inches over all, including the coupling tube. The 10 sections are used for the mast itself, 3 sections for the shelter tent when erected, and 1 extra section for use in case one of the others becomes unserviceable.

When starting to erect the mast, the four antenna wires and guys should be laid out on the ground at right angles to each other and the umbrella insulator put on the upper end of the section that is not provided with a coupling tube. This section should then be raised and eight more sections with coupling tubes added, section by section, the tenth and last section being the one provided with the insulator fixed at the bottom end. During the erection the mast should be kept as nearly vertical as possible by the men holding the distant ends of the antenna guy ropes. Owing to the liability of the mast to buckle, no attempt should be made to erect the entire mast at one time; that is, by coupling all sections together and raising by means of the guys.

Antenna and Counterpoise

The standard antenna is of the umbrella type with four radiating wires, each 85 feet long, suitably insulated at the open ends and held as nearly horizontal as possible by guy rope extensions, each 85 feet long, the outer ends of which are made fast to ground pins. The standard counterpoise has four radiating insulated wires, each 100 feet long, laid out on the ground under the antenna wires. Both antenna and counterpoise wires are carried on hand reels for convenience in packing and quick reeling and unreeling in setting up and taking down the mast.

Generator

The generator is a hand-driven, 18-pole, alternating-current machine having an intermittent output of 250 watts at 110 volts and 500 cycles at a speed of 3333 R. P. M. It is self-excited, the exciting current for the fields being generated by a small shunt-wound direct-current machine, the armature of which is mounted on the same shaft as the alternator armature. The exciter has two poles and delivers the direct current at about 110 to 150 volts. The whole machine is driven by two handles, which should be turned at the rate of 33 R. P. M. to give the necessary armature speed of 3333 R. P. M., the combination gear having a ratio of about 100 to 1. The direction of rotation of the handles must be as shown by the arrow on the top of the gear case, as otherwise the machine will not deliver any current. The whole is inclosed in a dust-proof aluminum case. To obtain access to the commutator, remove the flywheel, taking care not to lose the key on the flywheel shaft; then remove the large brass nut and the aluminum disk held in place by the latter, after which it will be found that the commutator is readily accessible. To remove the armature from the machine, proceed as above; then take off the casing covering the spur gears at the opposite end of the shaft, and the gears themselves; before removing the armature take the brushes out of the holders to avoid injuring or breaking them.

The tension on both sets of the generator brushes should be kept as light as possible consistent with good commutation. A small increase in the friction of these brushes will require considerable additional power to drive the machine. Both sets of brushes can be removed when necessary through openings in the lower part of the case, the D. C. exciter brushes being at the flywheel end and the A. C. brushes at the opposite end.

A canvas cover is provided for the generator, which should be kept on at all times when the generator is not in use.

Speed Indicator

A speed indicator is mounted on the upper part of the gear case in sight of the men driving the machine so as to show if it is being driven at the proper speed, at which time the red line on the moving vane coincides with the black index or arrow at the window. The vane is divided diagonally into black and white parts, the white showing if the speed is too low and the black if too high.

In putting the speed indicator in place it may be necessary to turn handles slightly so as to permit the gears to engage.

In case the vane of the speed indicator comes on the underside when the indicator is screwed into place, it can be turned into proper position after loosening the depressed set screw on the threaded part fitting into the case and then tightening the set screw again.

In making the set ready for transportation, the speed indicator should be removed and packed in its proper place in the operating chest and the opening closed with the brass plug provided.

Gearing

The gearing is a combination planetary worm-and-spur type of high efficiency when in proper alignment. The high-speed shafts have ball bearings and the gears run in grease or oil so as to reduce the friction as much as possible. The gears should never be taken apart unless absolutely necessary to replace worn or broken parts, and then only by an experienced person. If not properly reassembled, or if the driving gear does not run perfectly true with the worm, undue friction and wear will result, the machine will be harder to turn than before, and the gears will be speedily destroyed.

The gears and ball-bearings can be lubricated by either a nonfluid oil or a light, thin oil, such as Medium Monogram, but both must be free from acid and water to prevent rusting. If oil is used it should be supplied through a small cap on the opposite side of the case from the speed indicator. The level should be kept not more than one-eighth inch above the *lower edge* of the glass window at the flywheel end of the gear case; if kept above this, the oil will overflow to the lower part of the case and cause trouble and sparking at the commutator and collector rings. The same kind of oil should be used on the flywheel shaft through the small hole on the upper side of the bearing.

If nonfluid oil is used it should be supplied through the opening where the speedometer is screwed into place. Not less than a pint nor more than a quart should be used in the main gear case, but only a small amount in the spur gear case at the end opposite the flywheel, as otherwise the machine will turn hard on account of choking the gears with too much nonfluid oil in the narrow gear case.

With the exception of an occasional addition of oil, the machine should run for months without attention. If the oil becomes thick or dirty, the gearing should be washed out with gasoline and refilled with clean oil *without dismantling.*

Care must be taken *not* to *start* or *stop* the machine *suddenly,* as this may strain or break the gears. The machine must *not* be stopped by means of the handles, but *only* by *friction on the flywheel.*

Connections

The leads from the armature of the A. C. generator are directly connected to the transformer primary by means of the heavy pair of leads, the larger plug of which being put into the socket at the left-hand end of the operating chest marked "Gen." and the smaller plug into the socket on the underside of the gear case, also marked "Gen." The sending key is in the circuit of the alternator fields and the exciter armature, and is so connected by means of the light pair of leads, the larger plug of which being put into the socket at the left end of the chest marked "Fld." and the smaller plug into the socket on the underside of the case, also marked "Fld." By the use of these circuits, the electrical load on the machine is limited to the small one of the exciter field, except when the key is closed in sending. Experiments have shown that twice the output of the former machines can thus be obtained with practically no more tiring effects on the men than before.

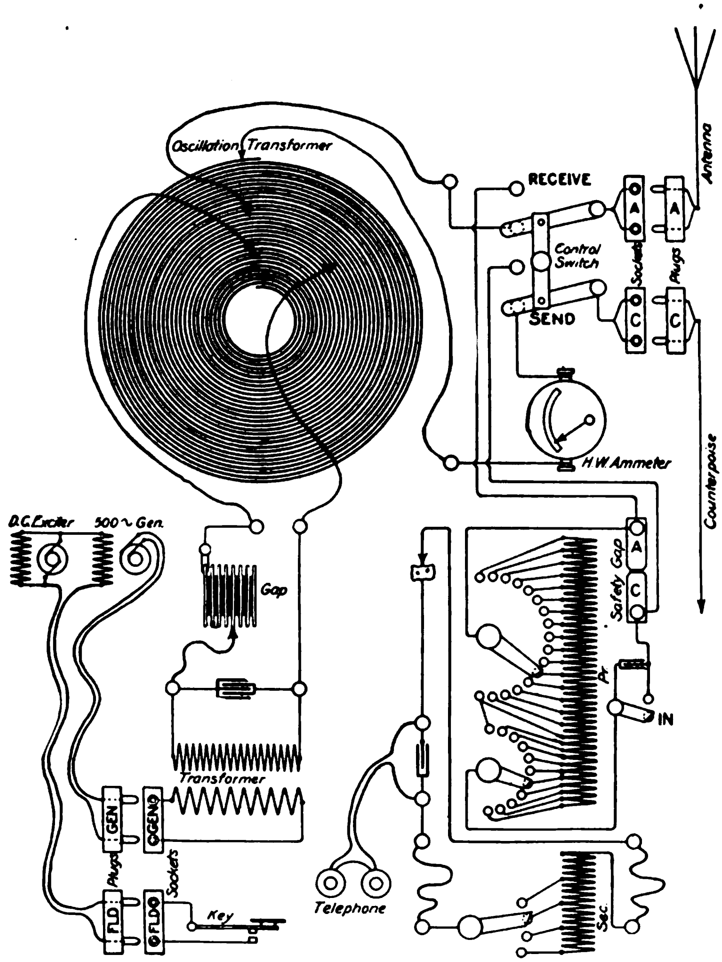


Figure 1—*Field Radio Pack Set, model* 1913

Operating Chest

In this chest is mounted the transmitting and receiving apparatus, the diagram of which is shown in Figure 1. To put the chest in condition for sending, connect the double contact plugs of the leads from the hand generator, field, antenna, and counterpoise to the receptacles marked "Gen.," "Fld.," "A," and "C," respectively, and the four variable contact clips on the leads from the condenser, spark gap, antenna, and hot-wire ammeter, to the four points on the flat spiral, as indicated on the diagram, making sure that the counterpoise clip is at the end of the outside turn. Set the control switch at the "sending" or lower position. Release the indicating needle of the ammeter by turning the small knurled screw at the left-hand side of the upper binding post. When the needle is free, adjust to zero position on the scale by means of the small knurled screw at the right side of the upper binding post. Set the variable spark-gap contact on the fifth plate, counted from the left end, so as to put *four gaps* in circuit. Start the generator, and when the proper speed is obtained the set is ready for sending.

Quenched-Spark Gap

The spark gap used in this set is made up of several copper disks separated by mica washers about 0.01 inch thick. Its action is to allow all of the energy of the closed oscillating circuit to be transferred to the open or radiating circuit in a few oscillations, after which the spark is quenched and the circuit is, in effect, open. The activity in the closed circuit having ceased, the open or radiating circuit continues to oscillate at its own period, radiating waves of its own wave length without any retransfer of energy to the closed oscillating circuit, which continues to remain open until a spark breaks down the gap again at the peak of the next alternation.

In order to work at maximum efficiency, the quenched-spark gap should be kept cool. It is for this reason that the plates are provided with thin cooling flanges having a large surface exposed to the air, and are blackened, a black body cooling more rapidly than one highly polished. If the gaps have become too hot, as by keeping the key closed for a long time, the antenna current will gradually decrease, the loss at times being as much as 40 per cent, so that it is always best to allow the gap to cool before using again.

The gap should not be taken apart to clean its sparking surfaces like an ordinary type of open gap. In general the more frequently such a gap is opened the more unsatisfactory may be its operation. The explanation is that the repeated opening of the gaps introduces air each time, and that with free exposure to air the sparking surfaces are corroded or pitted, but that when kept air-tight they are worn smooth and clean by the sparking action. Sometimes, if there is a flaw in one of the plates or if air leaks into the gap, there will be a noticeable drop in the antenna current, and the note will become poor. When it is believed that the trouble is confined to one or two gaps it is possible to continue sending without dismounting the whole gap by short-circuiting the bad gaps by means of clips provided for the purpose, in which case as many new gaps must be put into circuit by adjusting the movable clip to the right as were cut out by the short-circuiting clips.

The gap should be dismounted *only* when the trouble has been located in the gap and it has been found impossible to remedy it by short-circuiting the different gaps in use. The gap should be dismounted only by an experienced man, who should clean the surfaces by rubbing them face down on fine emery cloth or paper on a *flat surface*. It is absolutely necessary that both the bearing surface and the sparking surface be kept true and plane, as shown by a straightedge.

Great care should be exercised in reassembling the gap to set the mica washers accurately on the annular surfaces of the disk and to put on enough tension with the clamping screws to render all of the gap spaces air-tight.

Tuning of Sending Set

The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter. In the present type of directly coupled set with a flat spiral as the oscillation transformer, these adjustments can be made either with or without the help of a wave meter. If made without the meter the adjustments are more difficult and must be found by trial, but they should satisfy the following tests: (1) The number of turns in the closed circuit should be chosen so as to give the desired wave length; (2) the antenna hot-wire ammeter should show the maximum reading that can be obtained by adjusting the number of turns in the open circuit according to the table given later; and (3) the note as heard in the telephones of the receiving set should be clear and characteristic of 500 cycles. These adjustments are, in general, dependent on each other, an incorrect change in one seriously affecting all the others; but when obtained the circuits will be in resonance at the desired

wave length, they will be correctly coupled, and the closed-circuit condenser will be charged and discharged regularly once per alternation.

The adjustments should be made as follows: Set the closed and open circuit clips on the turns corresponding to the desired wave length. These turns are approximately correct with the standard antenna and should be used in beginning to make the adjustments. If the antenna ammeter reads between 2.2 and 3.0 amperes and the note is clear and of 500 cycles, then the adjustments are correct and the circuits properly tuned. If the ammeter reading is low and the note low and clear or low and ragged, possibly the circuits are correctly tuned, but there are too many gaps in circuit, and the condenser is being charged and discharged either regularly or irregularly only every second or third alternation. Reduce the number and see if this change gives a clear 500-cycle note, etc. Similarly if the note is high and hissing, the condenser is being charged and discharged more than once per alternation. Increase the number of gaps and see if this change gives a clear 500-cycle note, etc. If none of these changes gives the correct adjustments, then the circuits are not in resonance, or the coupling is wrong. Move one of the *open-circuit* clips to see if the correct adjustments can be obtained; it is impossible to state which clip should be moved or in which direction. If the change of one clip is not sufficient, move both *open-circuit* clips until, by repeated trials, the correct adjustments have been found. If possible, leave the counterpoise clip on or near the outside turn, so that it will be at ground potential. It will be found that the character of the note will be changed as these various changes in coupling and tuning are made, but the clearest 500-cycle note will be obtained when all adjustments are correct and the circuits properly tuned. After the adjustments have been completed at this wave length, tabulate the results as shown and repeat at other wave lengths within the range of the spiral.

Although there is no direct test that can be applied, except with a wave meter, to determine if a single wave length is being radiated, yet in general this will be the case if the adjustments satisfy the tests.

If a wave meter is available the adjustments are much easier to make, and they should satisfy the following tests: (1) A single sharply defined wave should be radiated of the desired wave length, (2) the antenna ammeter and the signals in the telephones of the meter should show the maximum reading and signals obtainable under the first condition, and (3) the note should be clear and of 500 cycles.

It will probably be best to use the wave meter with a detector or helium tube, because it will be impossible to turn the hand generator at a sufficiently constant speed to obtain steady readings on the wattmeter and hence difficult to determine the resonance point and wave length.

The adjustments for tuning should be made as follows: Disconnect the open-circuit clips and set the closed-circuit clips on the turns corresponding to the desired wave length. Measure the wave length according to the instructions just given to make certain that it is correct. Set the open-circuit clips on the turns given in the table, and, with the wave meter near the antenna or counterpoise wires, but near the spiral, see whether there is one wave length or two in the meter. If there is a single sharply defined wave length, and the antenna ammeter reading can not be increased by slight changes of either or both of the *open-circuit* clips and the note is clear and of 500 cycles, then the adjustments are correct and the circuits properly tuned. If there is only one wave length, but the antenna ammeter reading is low and can not be increased by slight changes in the open-circuit clips, then the coupling is too loose and must be tightened. Move the *open-circuit* turns in use inward as a whole, by moving both clips inward and slightly increasing the number of turns in circuit to allow for the decrease in their diameter, until with a single sharply defined wave length the antenna ammeter reading is a maximum,

etc., as before, in which case the circuits are properly tuned. If the note is low, decrease the number of gaps; if high and hissing, increase the number as previously described. If, however, there are two wave lengths, move one or both of the *open-circuit* clips, but it is impossible as in the previous case to state which clip or in which direction, until by repeated trials it has been found that there is a single sharply defined wave length, a maximum antenna ammeter reading, etc., as before, in which case the circuits are properly tuned.

After the adjustments have been completed at this wave length repeat at other wave lengths as before and tabulate the results.

If the one-eighth or one-fourth kilowatt motor-generator or the engine-driven one-fourth kilowatt generator supplied by the Signal Corps, is available, it should be used as the source of the 500-cycle current because its voltage will be much steadier than that of the hand generator. When the motor-generator set is used, the A. C. armature and the D. C. motor should be protected from "kickbacks" due to the use of the sending key in the alternator fields by two high-resistance carbon rods mounted on suitable bases to be connected as follows: The end terminals of one rod to the two A. C. leads close to the machine; the end terminals of the other rod to the two main line D. C. leads close to the machine, and the middle points of both rods to be connected together and this common point grounded on the frame of the machine.

The constant speed of the motor-generator makes it possible to get steady readings on the wattmeter of the wavemeter, and hence easy to find the resonance point and wave length. It may also be more convenient than a detector because it is often difficult to keep a detector point in sensitive adjustment on account of the nearness of the spark gap and to determine the resonance point on account of the continuous note in the telephone. However, the detector and helium tube can be used if desired; the circuits will be correctly tuned no matter what means are used for determining resonance. The circuits should be adjusted to resonance, etc., as described in previous paragraphs.

In some cases it may be convenient to use the following slight modification of the method described. Disconnect the transformer secondary from the closed circuit and connect it to the two terminals of a small zinc or brass spark gap, one of which is connected to the counterpoise and the other to the standard antenna. Measure this wave length, which will be the fundamental wave length. Next insert, say, two turns of the spiral, Nos. 28 to 30, counting the turns from the inside turn outward, in series with the antenna, and measure this wave length. Continue in this manner until all wave lengths are measured within the range of the spiral and tabulate. Next make the standard connections, setting the open-circuit clips on the turns corresponding to the desired wave length, as just obtained. Set the closed-circuit clips on the turns given in the table which follows—"Short Waves," "Long Waves"—and make the necessary adjustments by moving these clips until it has been found by trial with the wavemeter that there is a single sharply defined wave length, maximum current in the antenna, etc., as before. Tabulate these results and repeat for wave lengths within the range of spiral. In this case the *closed circuit* is tuned to the open circuit, whereas in the previous case the open circuit was tuned to the closed circuit, but the same tuning points will be found for the same wave length, whichever method of tuning is used.

It is impossible to use exactly the same method as in this table, in which the number of turns for a given wave length is determined for both the primary and secondary circuits, after which the principal adjustment is one of coupling, because the number of turns in the primary circuit of the spiral at any wave length will depend on the part of the spiral which is included in the circuit, and hence it will vary with every combination of turns. It is for this reason that the primary tuning and coupling must both be found by trial.

Open-Circuit and Closed-Circuit Tuning

Wave length.	Antenna.	Counterpoise.
Meters.	*Turn No.*	*Turn No.*
300	26⅞	30
325	24⅞	30
350	22¾	30
375	20¾	30
400	18⅝	30
425	16⅝	30

Turns to be counted from the inside turn outward.

Wave Length.	Closed-circuit clips.	Open-circuit clips.
Meters.	*Turns.*	*Turns.*
300	8 and 12½	26⅞ and 30
325	8 and 13⅛	24⅞ and 30
350	8 and 13⅝	22¾ and 30
375	8 and 14⅛	20¾ and 30
400	8 and 14⅝	18⅝ and 30
425	8 and 15⅛	16⅝ and 30

Turns counted from the inside turn outward.

Although a transmitting set using the flat spiral oscillation transformer is not as easily tuned as some other types, yet when the adjustments have once been made and tabulated it is practically as efficient as other types. It has the advantage of being one of the simplest, most rugged, and compact forms which can be installed in a field set.

Receiving Set, Type B

The receiving set consists of an inductively connected transformer with broadly tuned secondary circuits, galena, or other similar detector, high-resistance telephones, etc., provided with the necessary switches for tuning to different wave lengths. The primary circuit includes the antenna, primary coil, series condenser or not as may be needed, and counterpoise. The antenna is connected to the primary coil through switches which put into circuit a variable number of turns, steps of 10 turns being inserted by one dial switch and single turns by the other. The total number of primary turns is thus the sum of the numbers on the two dials indicated by the two switch arms, which can be varied by single turns from one to the whole number in the coil. For wave lengths shorter than the fundamental wave length of the antenna, a fixed condenser is inserted in series with the primary coil by throwing the switch near the binding post marked "G" to the position "In," as shown in Figure 1. For the longer wave lengths the switch is thrown to the other position, short-circuiting the condenser, and thus leaving only the coil in circuit. The secondary circuit includes the secondary coil, detector, and the stopping condenser shunting the telephones. The coil is variable only by sections, marked "100," "200," etc., the smaller numbers to be used at the shorter wave lengths and the larger ones at the longer wave lengths. The position of the secondary coil within the primary—that is, the coupling—is variable, and for the sake of convenience a scale is provided so as to be able to note the different adjustments. The coupling is closest when the secondary is inside the primary, in which case the scale reading is 0, and vice versa, the coupling is loosest when the secondary is drawn outside the primary and the scale reading is 40.

Short Waves

Primary condenser in series.

(Switch on "In" contact.)

Wave length (in meters).	Primary turns.	Secondary turns.	Coupling scale.
200	18	100	20
300	26	200	20
400	36	200	20
500	47	300	20
600	60	300	20
700	74	400	25
800	88	400	30
Etc.	Etc.	Etc.	Etc.

Long Waves

Primary condenser short-circuited.

(Switch not on "In" contact.)

Wave length (in meters).	Primary turns.	Secondary turns.	Coupling scale.
300	24	200	20
400	30	200	20
500	38	300	20
600	46	300	20
700	56	400	25
800	65	400	30
900	76	400	30
1,000	91	400	25
1,100	107	400	25
1,200	125	400	30
1,300	144	400	25
1,400	162	400	25
Etc.	Etc.	Etc.	Etc.

Tuning of the Receiving Set

First, the detector must be adjusted to a sensitive point by means of the test buzzer, the note of which should be clearly heard in the receiving telephones when it is held near the antenna or counterpoise wires or the coil windings. When the wave length of the sending station is known, the number of turns in the primary and secondary coils and the coupling should be set according to the values in the above table, which will be approximately correct for all sets using the standard antenna. When the wave length is unknown, then signals can be found only by repeated trials of different combinations of turns and couplings, in which, however, *consistent* sets of values may be taken from the table. When once the signals have been heard such further adjustments of primary and secondary turns and coupling should be made as will give the maximum sound in the telephones. In general it will be found that when there is interference or static troubles the sharpest tuning and the best protection from interference will be obtained when the loosest coupling is used; that is, when the secondary is pulled out as far as possible and still hear the desired station. It will be noticed that for some wave lengths there are two different possible combinations in the primary circuit, either without a condenser and a few primary turns or with a condenser and more primary turns. It is impossible to tell which combination is the better without actual trial. In general the best coupling between the circuits will vary with the damping of the transmitting station, close coupling being possible with highly damped transmitters, and loose coupling necessary with feebly damped transmitters.

In changing the coupling between the two circuits by means of the handle

on the secondary coil care must be taken to see that the contacts on the various studs are not loosened, as otherwise the signals may be lost entirely or the tuning made much broader on account of high resistance that may be introduced at these contacts.

If the receiver is used with the standard antenna and signals are being received from an unknown station, the table of wave length can be used to determine approximately the wave length of the unknown station.

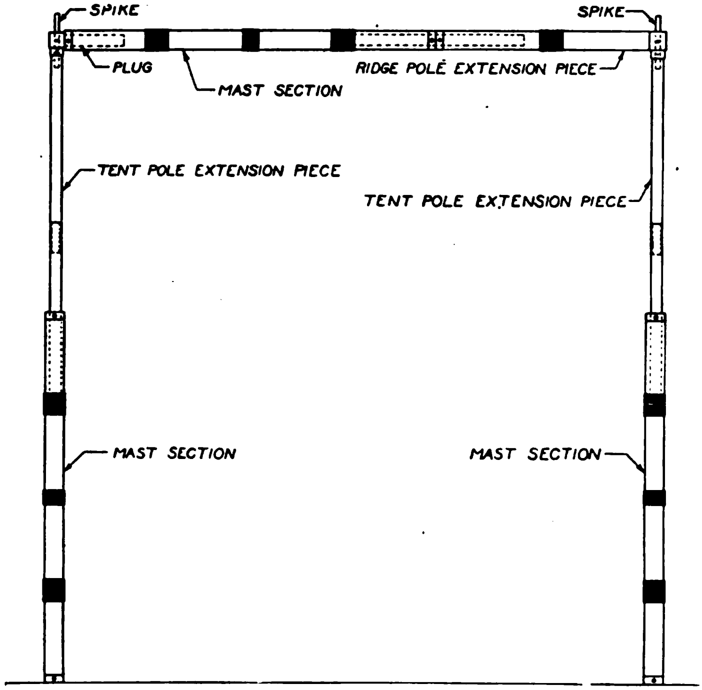


Figure 2—Shelter tent pole-erection

Shelter Tent

This tent is similar in dimensions and construction to the standard "common" wall tent issued by the Quartermaster's Department, but is made of lighter material and is not provided with ridge pole or uprights. In erecting the tent the extra sections furnished with the mast should be used as the ridge pole and uprights as follows: One hollow section, one plug, and one extension piece for the ridge, and one section, one extension piece with spike for each upright. The method of erection is illustrated in Figure 2.

Insulating Device

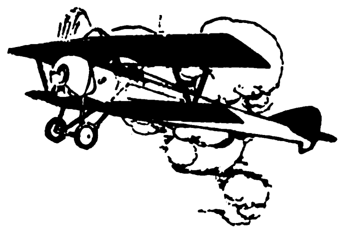
A device is provided for use in insulating the antenna when the shelter tent is used in damp weather, consisting of a square piece of sheet rubber with small marginal holes for lacing into the ventilator at either end of the tent, and a tube attached to the center for admitting the antenna lead. When in use, sufficient slack should be left in the antenna lead to form a drip loop outside of the tent, and if found necessary a piece of heavy insulated wire can be used as a leading-in wire.

Packing

The set is normally packed on three mules, but in emergency may be packed on two. In normal packing the first mule carries the generator and six sections of the mast. The second mule carries the operating chest, four sections of the mast, antenna, counterpoise, accessories, bag, etc. The third mule carries the tent, with tent pins and extension pieces folded inside, four sections of the mast, flag kit, lanterns, etc. In emergency packing with two mules, the first mule carries the generator and 10 sections of the mast, and the second the operating chest, four sections of the mast, antenna, counterpoise, and tent.

How to Become an Aviator

The Sixth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

THE student having mastered, through previous lessons in this series, the theory of flight and the fundamentals of design of aeroplane lifting surfaces and controls, knowledge of rigging is next in order.

As an infantryman's first care is for his feet, and a cavalryman for his mount, so must the military aviator know his means of locomotion, his aeroplane. The army does not require the dismounted soldier to be a chiropodist, or the cavalryman a veterinarian, no more than the aviator is expected to be an expert mechanic. But he must know whether or not his machine is in condition, and what he may expect of it, without recourse to another's judgment. With the engine out of order a safe landing can be made, but when something goes wrong with the rigging there is trouble ahead. Should the rigging be wrong, even though nothing breaks, speed is lessened and stability and control made less effective.

Rigging an aeroplane properly presupposes knowledge of the stresses it is subjected to and the strains which may appear. Aeroplane materials are of the size and weight which combine greatest strength and least weight. A knowledge of them is important.

Stress is the load which a body bears. It is generally expressed thus: $L \div A = S$, where L is the load, A the square inches contained in the cross-sectional area, and S the resultant stress. For example, with an object measuring in cross-section $3'' \times 2''$ (an area of 6 sq. in.) and required to support a total load of 12 tons, the stress would be $12 \div 6 = 2$ tons.

Strain is deformation produced by stress.

If a spar is known to collapse under a maximum stress of 1200 lbs., in a training machine it would be subjected to no greater stress than 100 lbs.; thus where known stress of an object is 1200 lbs, and the maximum stress it is called upon to endure is 100 lbs., then 1200 lbs. $\div$ 100 lbs. $=$ 12, representing:

The Factor of Safety, which is ordinarily expressed by the resultant of known collapsing strength divided by maximum stress the object is called upon to endure.

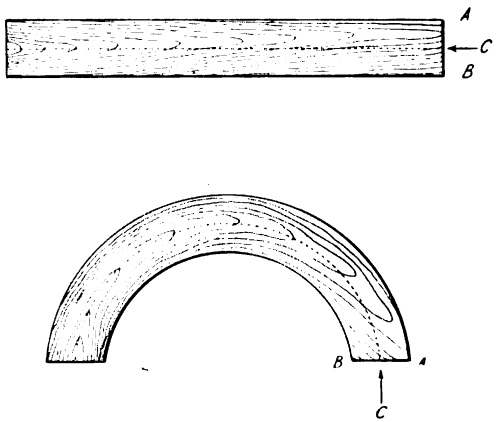


Figure 26—Compression and tension stresses produced by wood bending

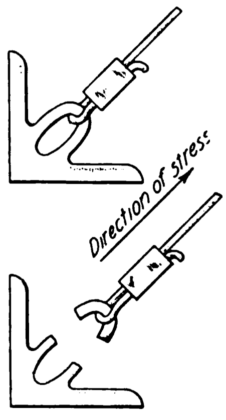


Figure 27—An illustration of shearing

STRESS AND STRAIN FORCES

Strength of materials must be understood from the viewpoint of strength in compression, tension, bending, torsion and shearing. For example, wire is designed to take tension but not compression, wood takes compression but not shearing, bolts are suited to shearing, etc.

Compression—The stress of pressure produces a crushing strain, best exampled by the stress on interplane struts.
Tension—The stress of pull, tending to elongation, exampled by all wires.
Bending—A combination of tension and compression exampled by the bending of wood, the outside fibres tending to pull apart, the inside to go together.
Shearing—A cutting off sideways by a pull such as is exerted on an eyebolt or pin.
Torsion—A twisting stress, a combination of the forces of compression, tension and shearing, such as is received by the propeller shaft.

Bending—Figure 26 illustrates how the combination of compression and tension stresses are produced by bending. The upper view shows a straight piece of wood, the top line (*A*), the center line, or "neutral axis" (*C*) and the bottom line (*B*) being all of equal length. In the lower view the same piece of wood is bent. Then center line (*C*) is still the same length, but the top line (*A*) is further from the center and therefore longer. This is due to the stress of tension producing the strain of elongation; the upper portion is therefore in tension, which increases with its distance from the center. Meanwhile, the bottom line, under the strain of crushing produced by the stress of compression, has become shorter than the center line. At the center line, therefore, there is neither tension nor compression and the wood nearest the center is under considerably less stress than that near the top and bottom lines. Thus the center may be hollowed out without appreciably weakening the wood, which makes it possible to save about 25 per cent. of the weight of the wood used in the construction of an aeroplane.

Shearing—In Figure 27 a wire exerting pull on an eyebolt is shown. The lower view illustrates how the stress may shear an eyebolt.

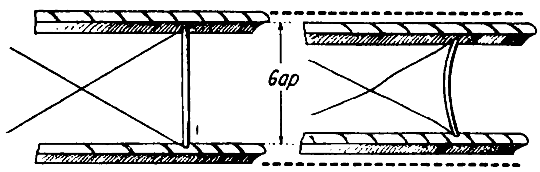


Figure 28-a *Figure 28-b*
Effect of strut bending under stress

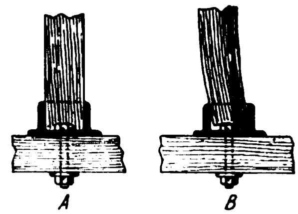


Figure 29
Strut properly and improperly bedded

STRENGTH OF WOOD UNDER STRESS

Upon the care exercised to have struts kept perfectly straight and evenly bedded into sockets rests the strength of wood under compression. A stick 1 inch in diameter and 36 inches long, if kept perfectly straight can perhaps bear a ton weight without breaking, but if it were not straight, or had started to bend, a compression of 50 pounds would break it. Weight being of the greatest importance in aeroplane design, the wooden parts are kept as far as possible in direct compression. To save weight is the aim of all designers and in consequence an aeroplane's factor of safety is ordinarily low. The required stresses for parts in direct compression may be safely taken, however, if they meet the requirements which follow:

Straightness—Spars and struts must be perfectly straight. Viewed in cross-section, these supporting members are elliptical in shape (stream lined); the center of strength is therefore midway between the points of greatest transverse width. If the stress of compression is not equally distributed about this point the strut will bend, because tension will be created on one side and compression on the other. The effect of a strut bending is shown in Figures 28-a and 28-b. In the former the wire stays are taut and the proper gap between wings maintained. With the strut bent, as in Figure 28-b, the gap is lessened and the wires have become slack, efficiency in flight being thereby lessened.

Fit—Struts and spars must fit their sockets accurately and be bedded correctly. While snugness is essential, the wooden portions of the structure must slide into their sockets or fittings by pushing; a hammer is never required. The bottom should fit the socket exactly. In Figure 29, strut *A* is correctly bedded; strut *B* is not snug at the bottom, in consequence of which the compression stress is not evenly distributed about the center of strength and a bending stress is produced.

In assembly, the customary test consists of painting the bottom of spars and struts before they are fitted to sockets; the paint must be distributed over the entire bed when the strut is withdrawn.

Condition—Struts and spars must be undamaged. If the wood is scored or dented, and the strut or spar should be subjected to a bending stress, the outside fibres receive the greatest strain (as explained on the preceding page) and the collapse will come at the imperfect point. Cross grain, knots and similar blemishes are prohibited for the same reason.

The wood must also be well varnished to keep the moisture out. Variation in the dampness of the atmosphere causes wood to expand and contract, the danger in this variation being that this expansion and contraction is not evenly distributed and the symmetry of the spar or strut is lost.

WOOD FOR AEROPLANES

Practically all of the aeroplane's framing is constructed of wood, one reason for this being that flaws can easily be detected; consequently, wooden parts are seldom painted, preservation being secured by the use of varnish which brings out clearly any defects. Lightness, strength and rigidity are the prime requirements for flying machine construction. Certain woods best fulfill these, better in fact than any metal. This may be illustrated by a comparison of spruce with aluminum, lightest of the metals.

A cubic foot of spruce weighs 27 pounds.
A cubic foot of aluminum weighs 162 pounds.
Tensile strength of spruce per square inch is 7,900 pounds.
Tensile strength of aluminum per square inch is 15,000 pounds.
Compression strength of spruce per square inch is 4,300 pounds.
Compression strength of aluminum per square inch is 12,000 pounds.

On the cubic foot basis, the weight of spruce has a decided advantage over metal. Aluminum's weight is 6 times greater; brass about 19 times greater; nickel and steel about 18 times; copper about 20 times.

While wood is not as strong as steel of the same size, the construction of struts requires a certain thickness in proportion to their unsupported length, so the use of spruce, although it offers by its size more head resistance, is to be preferred because strength against bending is secured with less weight.

Preferential woods for aeroplane work are Spruce, Ash, Pine, Maple, Walnut, Mahogany, Cedar and Hickory. The selection of the right kind of lumber is largely a matter of experience, but the fundamentals are soon acquired with application to the subject.

Spruce—The strongest and most generally satisfactory material when clear grained, straight, smooth and free of knot holes and sap pockets. Combining flexibility, lightness and strength, it is used for struts and spars.

Ash—A straight-grained wood, strong in tension, springy, but heavier than spruce. It is used for main spars, longerons, engine supports, rudder post, etc.

Maple—A strong wood suitable for small parts such as the blocks to connect rib pieces across a spar.

Hard Pine—A tough and uniform wood adapted for the long braces in the wings.

Walnut and Mahogany—Uniformity, hardness and finishing qualities are the reasons for extensive use of these woods for propellers.

Cedar—Lightness, uniformity and easy working qualities recommend this wood for occasional use in fuselage covering. Three-ply wood, or veneers, are sometimes used.

Hickory—Tough, hard and springy, this is the favored material for skids and landing chassis struts.

Condensed Table of Weight and Strength

U. S. Government Specifications

Wood	Weight per cubic foot (15% moisture)	Modulus of rupture, pounds per square inch	Compression strength, pounds per square inch
Hickory	50	16,300	7,300
Ash	40	12,700	6,000
Walnut	38	11,900	6,100
Spruce	27	7,900	4,300

Linen and cord are used for wrapping wooden members to increase strength against splitting; the winding is made very tight and treated with "dope" or glue for waterproofing and also to increase the tightness. Wooden parts are ordinarily ferruled at the ends, usually with copper or tin, to prevent the bolt pulling out with the grain, to prevent splitting and to supply a uniform base.

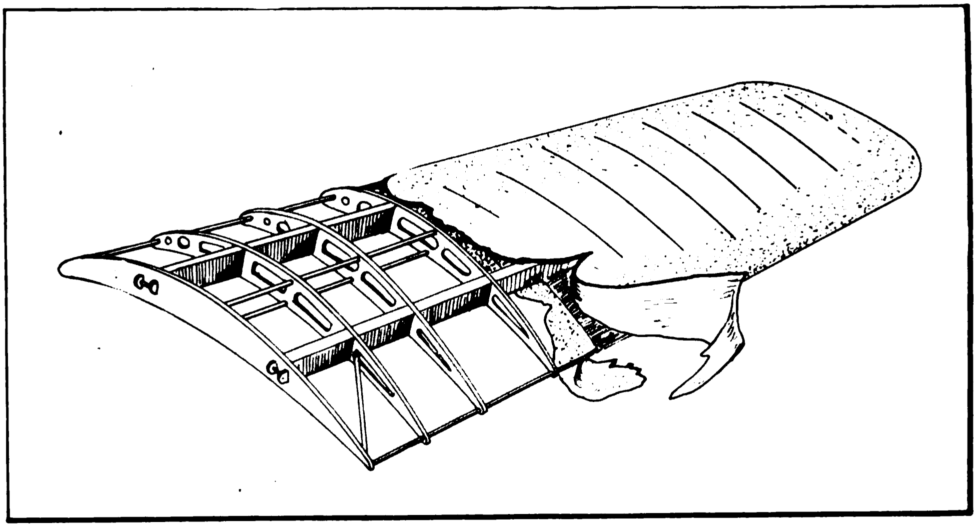


Figure 30—View of wing surface and method of applying covering

WING COVERING

Unbleached Irish linen, stretched rather loosely on the frame of the wing and then treated with "dope," is the almost universal covering for aeroplane lifting surfaces.

This fabric is woven with the "warp" of the yarn lengthwise and the "weft" across the cloth. It tests to a 60 pound tension on an inch-wide strip, and when doped shows a strength of at least 70 pounds per inch. It ordinarily weighs 3¾ to 4¾ ounces per square yard. Doped and finished, aeroplane linen weighs about 0.10 pound per square foot, inclusive of tape and varnish for both top and bottom faces of the surface.

Rubberized fabrics, formerly used, were discarded because of the necessity for stretching them tightly by hand on the frame, and because they tightened in dampness and sagged in dry weather.

The strips of the linen wing covering are sewed together by machine, forming a bag which slips easily over the framework, seams running diagonally across the wing. Figure 30 illustrates a partial covering on the wing framework.

DOPE

Dopes for coating linen wing coverings are of several kinds, but all are some compound of cellulose acetate or nitrate, soluble in ether or in aceton. Through doping, the linen is tightened up on the frame and given a smooth, weather-resisting finish.

The United States Army requires four coats of nitrate dope, this covering being varnished with two coats of spar varnish after the dope has set; this acts as waterproofing and protects the dope from peeling. Doped fabrics are best cleaned by soap and water.

Trade names of commercial dopes include: Cellon, Novavia, Emaillite, Cavaro and Titanine.

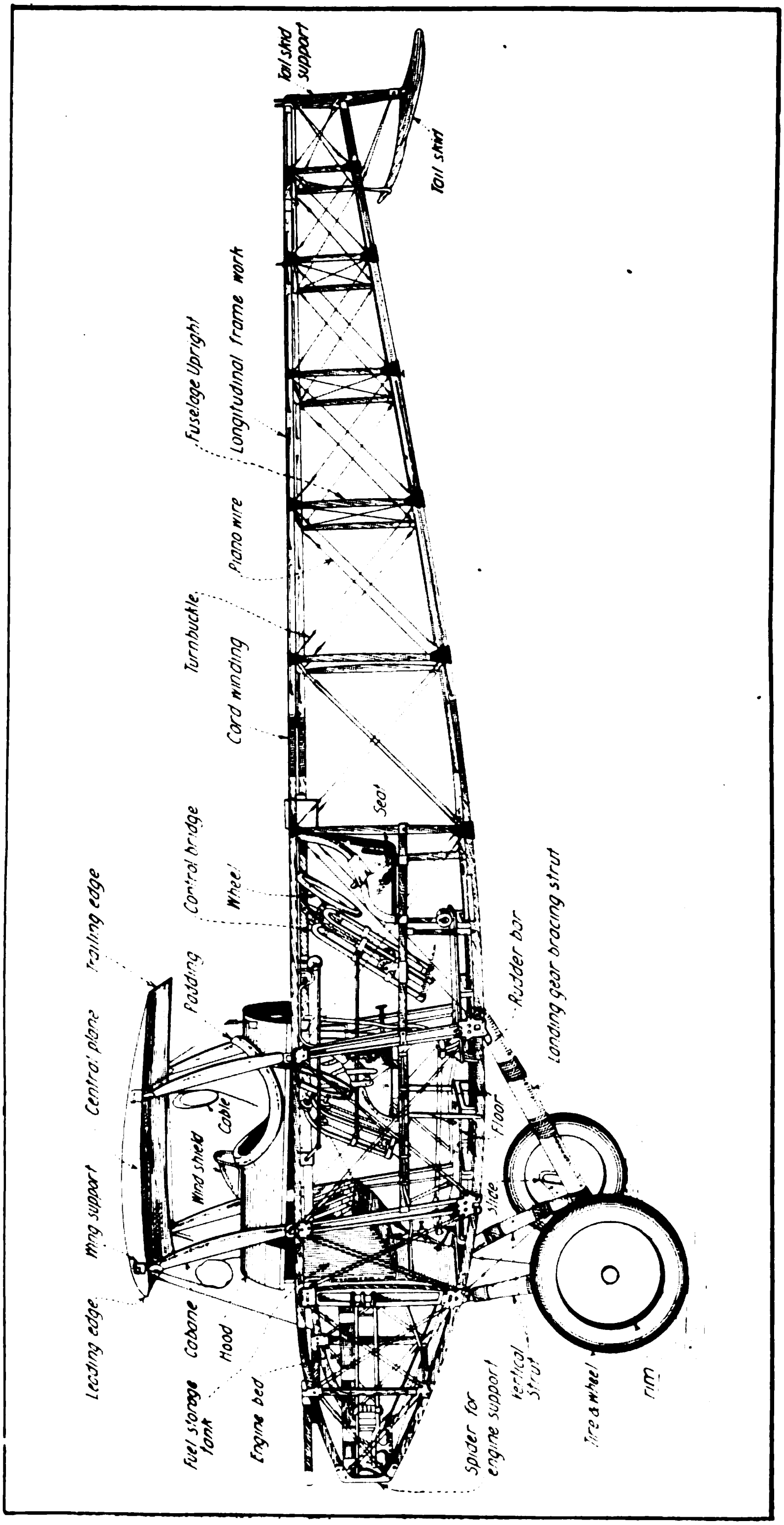


Figure 31—General view of an aeroplane with fuselage covering removed, showing details of body construction.

METAL FITTINGS AND WIRE

STEEL

Chrome nickel or vanadium steel, specially heat-treated, is often used for bolts, turnbuckles and pins. When parts are to be bent, special care must be taken that the heating is not done unequally. Serious weakening may result.

Cold rolled steel, used largely for ferrules, clips and fittings in aeroplane construction, is harder than mild annealed steel, works easily and wears well. Its grain is well marked and it should be remembered that it is weakest across the grain. Sharp bends should never be made and, unless one is familiar with annealing, any required bend should be made slowly in a vise. The jaws of the vise should be protected by thick copper pads to prevent nicking the plate.

OTHER METALS

Copper and tin are used for tanks and ferrules of wire joints.

Where rust resisting qualities are essential on metal fittings, "monel" metal is extensively used. It is composed of 60 per cent nickel, 35 per cent copper and 5 per cent iron.

Aluminum is unreliable and is never used in important fittings.

Metal is subject to crystallization and fatigue.

Crystallization—Constant vibration and jarring which causes easy breakage at a particular point.

Fatigue—Repeated strains of bending and twisting result in loss of "springiness" of metal, lessening its strength. This is known as fatigue.

WIRE

Two types of wire are used on aeroplanes: solid-drawn, for all minor bracing purposes; flexible cable, for control, flying and landing wires.

Aviation wire—This is a single wire, piano grade. While it is strongest for its weight, it forms kinks easily when coiled and may be seriously injured by a blow. Its main use, therefore, is for braces in the protected fuselage and wings.

Aviator strand—This is 7 or 19 wires stranded together and used for tension wires because of its elasticity, permitting it to be bent around parts of small diameter.

Tinned aviator cord—This is a cord or rope stay, composed of seven strands of 7 or 19 wires twisted into a rope. The wires are galvanized as a protection against rust, but where the heat required for galvanizing will injure hard or small wires, they are tinned. It is in general use for controls, and although less strong as the same size in single wire, has the advantage of not being seriously injured by a single weak spot.

The seventh article of this series, which will appear in the February issue, will deal with the assembly of military aeroplanes, describing practical erection and rigging.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE IX

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE.—This is the ninth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

COUPLED TRANSMITTER CIRCUITS IN RADIOTELEGRAPHY

METHODS OF COUPLING

(1) We have explained in previous lessons how a wireless telegraph aerial may be set into excitation by a **high voltage transformer** or an **induction coil.**

(2) Marconi observed that more powerful oscillations can be made to flow in the aerial circuit of a wireless telegraph transmitter by first generating the radio-frequency currents in a **closed oscillation circuit.** On account of the increased capacity of the closed circuit over that of the aerial circuit, it permitted the use of larger power inputs for the same wave length, spark frequency and voltage.

(3) Hence the **"plain aerial"** or **"directly excited"** transmitter was soon replaced by the **coupled** transmitter.

(4) There are four general methods in spark telegraphy for setting the aerial wires into electrical oscillation:

(1) **By direct excitation;**
(2) **By inductive coupling;**
(3) **By conductive coupling;**
(4) **By electrostatic coupling.**

(2), (3), and (4) are also known as **indirect** methods of coupling. Each method will be discussed further on.

WAVE LENGTH AND FREQUENCY

(1) The student should recognize the relation between the **frequency of the oscillations** flowing in the **aerial** or **open oscillation** circuit and the **length of the radiated electrical waves.**

(2) If the frequency of the aerial current is known, then the length of the radiated wave is determined by the equation

$$\lambda = \frac{V}{N}$$

Where* λ = the wave length in meters;

V = the velocity of propagation of electric waves in meters per second;
= 300,000,000 meters per second;
N = the oscillation frequency.

Hence, if N, the oscillation frequency = 1,000,000 cycles per second, then the wave length $= \frac{300,000,000}{1,000,000} = 300$ meters.

Similarly, an oscillation frequency of 500,000 cycles corresponds to a wave 600 meters in length.

*Greek Lambda.

(3) It is manifest that currents of extremely high frequency radiate comparatively short waves, and those of low frequency, comparatively long waves.

(4) The longest wave length on record employed for wireless telegraph transmission is 18,000 meters. The frequency of the antenna current at this wave length must be $\frac{300,000,000}{18,000} = 16,666$ cycles per second, which is nearly a current of audiofrequency.

(5) The natural wave length of a simple vertical wire earthed at one end is approximately 4.3 times its length. Therefore a vertical wire 100 feet in length, if set into excitation, will radiate a wave 4.3 x 100 or 430 feet in length. Since one meter equals 3.25 feet, the wave length is approximately 130 meters.

(6) The natural wave length of an aerial can be computed from knowledge of its inductance and capacity. If its inductance L be expressed in centimeters (1,000 centimeters=1 microhenry) and its capacity C in microfarads, then

$$\lambda = 38\sqrt{L\ C}$$

Assume that by measurement the inductance of an aerial is found to be 100,000 centimeters and the capacity .001 microfarads, then the wave length $=38\sqrt{100,000 \text{x} .001}$ $=38\sqrt{100}=380$ meters. This is a fair average value for a ship's aerial.

(7) The **wave lengths** allotted by the International Radio Telegraphic Convention for **ship use** are 300 and 600 meters. Either of these waves must be used for calling another station, but after communication is established, waves of any length between 300 and 600 meters may be employed.

Waves from 600 to 1,000 meters in length are used by Naval stations for ship to shore communication.

By special permission, vessels may, under exceptional circumstances, be granted licenses to employ waves in excess of 1,600 meters.

High Power stations for continent to continent communication employ waves up to 15,000 meters in length. The latter figure corresponds to a wave more than nine miles in length.

(8) We frequently speak of the **wave length of the closed oscillation circuit.** Reference is made to a particular frequency of oscillation, and the length of a single wave in the resulting wave motion if the circuit were radiative. Thus, if the frequency of a given closed circuit is 1,000,000 cycles per second it would correspond in the case of a radiating circuit to a wave 300 meters in length.

(9) It is essential that the open and closed oscillation circuits of a radio transmitter be adjusted to the same **natural frequency of oscillation or the same wave length.** They are then said to be in **electrical resonance** and it is only when they are substantially so adjusted that the maximum transfer of energy from one circuit to the other is obtained.

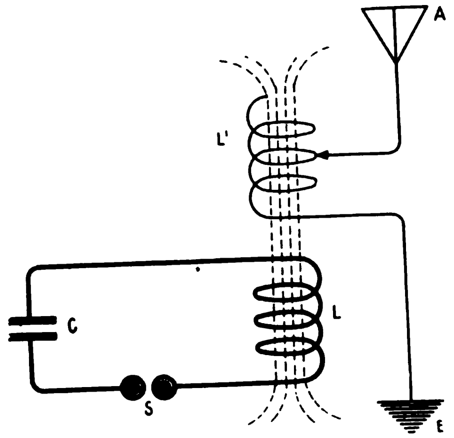


Figure 82

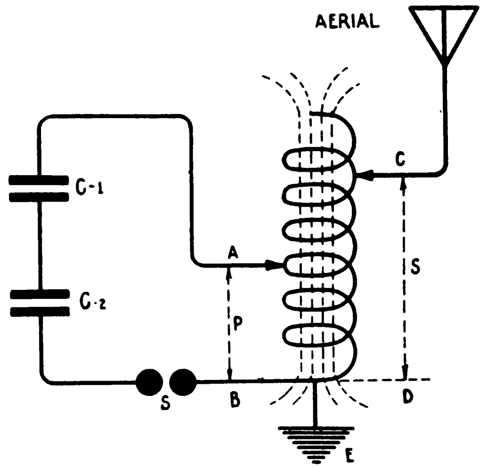


Figure 83

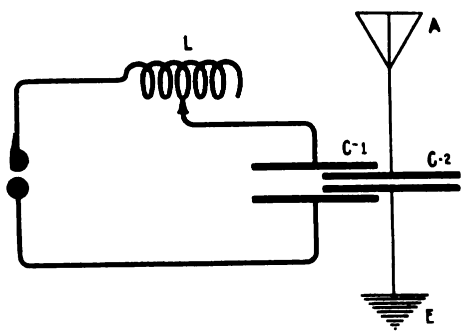


Figure 84

OBJECT OF THE DIAGRAMS

(1) To indicate the various modes of coupling the closed and open circuits of a radio transmitter.
(2) Figure 82. To show the circuits of an inductively coupled transmitter.
(3) Figure 83. To show the circuits of a conductively coupled transmitter.
(4) Figure 84. To show the circuits of an electrostatically coupled transmitter.

PRINCIPLE

Very powerful oscillations can be set up in an aerial circuit by generating them in a closed oscillation circuit which on account of its increased capacity permits more power to be employed for the same spark frequency and voltage. These oscillations are transferred to the aerial circuit through an oscillation transformer by electromagnetic induction.

DESCRIPTION OF THE DIAGRAMS

In Figure 82 the closed oscillation circuit consists of the condenser C, the primary winding of the transformer L, and the spark gap S. The **aerial** or **antenna circuit** includes the elevated wire A, the secondary winding, L^1, and the earth connection E.

In Figure 83 a single coil acts as an **auto-transformer** to transfer energy from the closed oscillation circuit to the open circuit. The closed circuit consists of the condensers C-1, and C-2 connected in series, the spark gap S, and the primary winding of the oscillation transformer which comprises the turns A to B. The secondary winding of the oscillation transformer comprises the turns C to D, the complete open circuit including the secondary coil, the antenna, and the earth connection.

In Figure 84 the closed oscillation circuit embraces the spark gap, the tuning coil L, and the condenser C-1. The open circuit comprises the aerial A, the aerial **condenser** C-2, and the earth connection E.

OPERATION

In Figure 82 the radio frequency oscillations flowing through the coil L generate a magnetic field which cuts through the turns of L^1 inducing therein oscillations of the same frequency, and if the circuits are in substantial resonance the maximum transfer of energy takes place.

In Figure 83 the flux generated by the current flowing through turns A to B acts inductively on the remaining turns of the coil setting up in the aerial circuit oscillations of similar frequency. Part of the energy of the closed circuit, however, flows into the antenna circuit by direct conduction.

In Figure 84 the electrostatic field set up between the plates of the condenser C-1 acts inductively upon the plates of the condenser C-2, the oscillations generated in the closed circuit thus being impressed upon the open circuit. This diagram represents coupling by electrostatic induction; direct or conductive electrostatic induction may also be used.

QUES.—Which of the methods of coupling shown in Figures 82, 83 *and* 84, *is most extensively employed in commercial wireless telegraphy?*

ANS.—The inductively coupled system is employed in the majority of installations.

QUES.—Why is this so?

ANS.—Because the inductive method permits the character of the radiated wave to be closely adjusted with the greatest ease. To illustrate: If the primary winding L is placed close to L^1 the aerial circuit will radiate a broad wave which will interfere with receiving stations not accurately tuned to its wave length; but if the primary winding L is drawn away from L^1 a sharper wave will be radiated which will only influence receiving stations accurately tuned to it.*

QUES.—What is the advantage or disadvantage of the conductive method of coupling?

ANS.—The principal advantage lies in its simplicity, a single coil being employed to act as the oscillation transformer. The principal disadvantage is that unless the earth connection is supplied with a special contact clip any change in the wave length of the open and closed circuits will change the coupling. That is to say, the same coupling cannot be held as the inductance of the open and closed circuits is increased or decreased. More clearly, it is difficult to obtain a certain degree of coupling without destroying the adjustments for resonance.

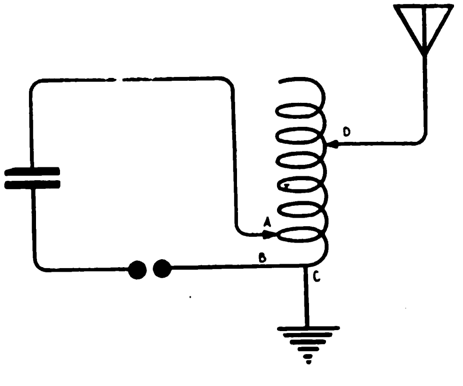


Figure 85

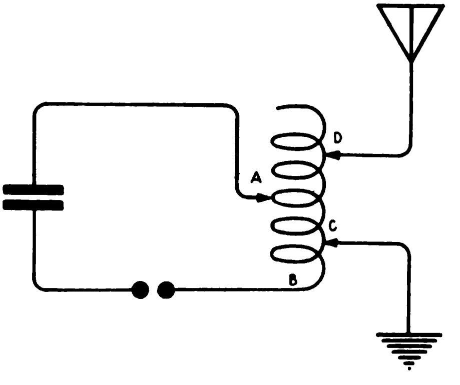


Figure 86

Figures 85, 86*—Showing the possible conditions under which loose coupling may be obtained with an auto-transformer. In Figure* 85 *the turns connected in the aerial circuit from C to D may be placed at the upper end of the coil and those connected in the closed oscillation circuit A to B at the lower end of the coil. This decreases the* **mutual inductance** *between the primary and secondary turns and therefore reduces the coupling.*

In the diagram Figure 86 *the capacity of the condenser of the closed oscillation circuit is such that in order to establish resonance with the aerial circuit not more than a half turn of the oscillation transformer between points A and B is required. Hence, the mutual inductance is at a minimum and the coupling is accordingly decreased.*

*This point will be explained more in detail in connection with the spark dischargers of modern transmitters.

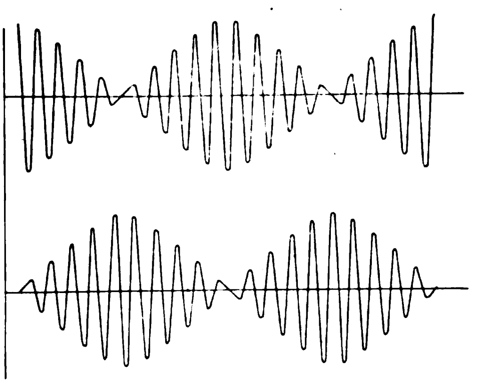


Figure 87

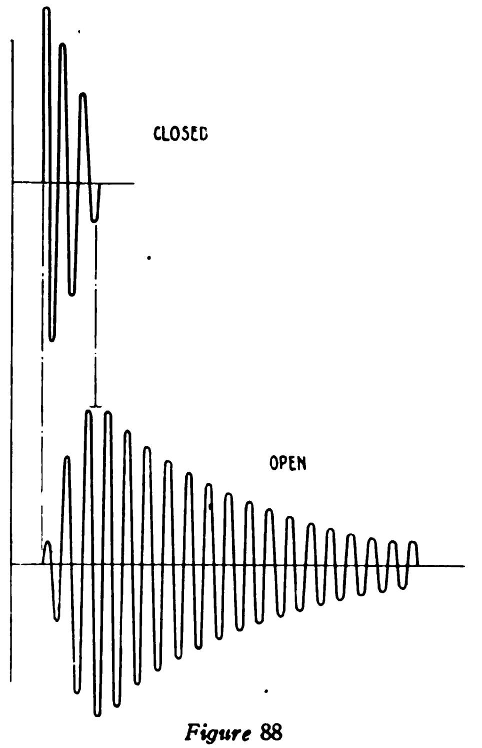


Figure 88

OBJECT OF THE DIAGRAMS

(1) Figure 87. To show diagrammatically the resulting oscillations in a coupled wireless telegraph transmitter in which the spark gap gives imperfect quenching of the primary oscillations.

(2) Figure 88. To show the resulting oscillations in a properly adjusted wireless telegraph transmitter, i. e., (1) where the discharge gap is constructed for quenching or (2) where the coupling is sufficiently loose to assist the quenching of an improperly cooled gap or an improperly designed transmitter.

PRINCIPLE

By proper design of a wireless telegraph transmitter, the oscillations flowing in the closed circuit can be quenched out after two or three swings. The aerial circuit will then be set into oscillation at its own frequency and damping, and the radiated energy will be confined to a single wave length.

If the spark gap does not quench properly or if the coupling between the primary and secondary of the oscillation transformer is too close there will be an interchange of energy between the secondary and primary circuits which will cause the circuits to oscillate at two frequencies. The aerial will, therefore, radiate two waves of different length.

DESCRIPTION OF THE DIAGRAMS

In Figure 87 are shown the resulting antenna oscillations generated by a transmitter in which the spark gap does not quench properly. It will be noted that when one group of oscillations reach their maximum value, the other group are nearly at zero. In the sense of a complete second, these two groups of oscillations occur simultaneously, but in the sense of a small fraction of a second they do not reach their maximum amplitudes simultaneously.

Figure 88 depicts the oscillations in the closed and open circuits in a properly adjusted transmitter, i.e., one where reliable quenching takes place. Here the closed circuit oscillates until the antenna currents reach their maximum value. Then the oscillations of the closed circuit, due to the sudden increase of the spark gap resistance, are quenched out permitting the antenna to oscillate at its natural frequency and damping. A single wave is therefore radiated.

SPECIAL REMARKS

(1) Quenching of the primary oscillations can be obtained with practically any type of transmitter provided the coupling is sufficiently loose, but in properly constructed spark dischargers, good quenching can be obtained with very close coupling and hence a greater amount of energy is transferred to the antenna circuit resulting in a more efficient transmitter.

(2) The best gaps for quenching the primary oscillations are the so-called **"quenched"** or **multiple plate gaps** and **the rotary gaps**. The quenched gap consists of a number of copper plates the sparking surfaces of which are carefully ground, the plates being separated by an insulating gasket of approximately .01 of an inch in thickness. By providing a discharger consisting of several such **gaps** in series, the primary oscillations are rapidly quenched out and re-transference of energy from the aerial circuit to the closed circuit is thereby prevented. The quenching of the primary oscillations is probably due to the rapid dissipation of the heat of the spark discharge through the copper plates.

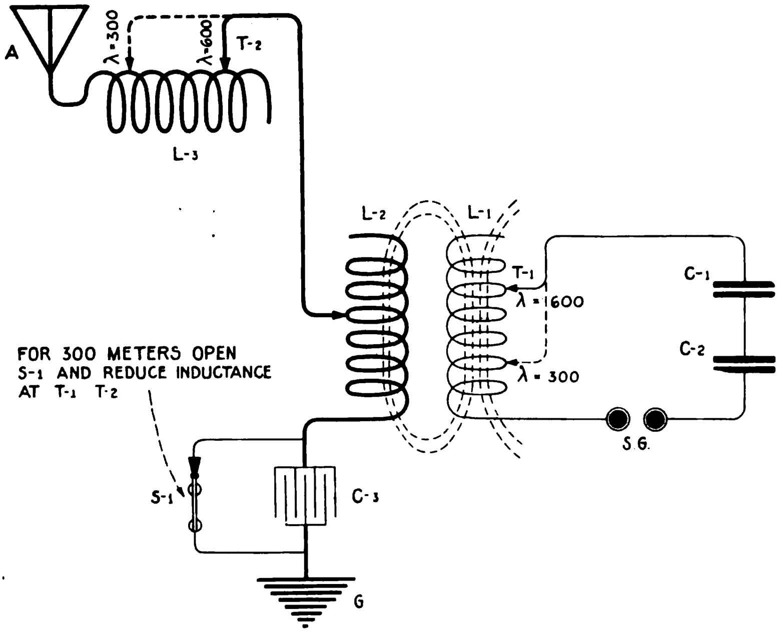


Figure 89

OBJECT OF THE DIAGRAM

(1) To outline the complete radio-frequency circuits of a spark transmitter.
(2) To show how the length of the wave radiated by a wireless telegraph aerial can be increased or decreased within the station.

PRINCIPLE

The length of the wave radiated by a wireless aerial may be increased by connecting a coil of wire (radio-frequency inductance) in series at the base, or it may be decreased by connecting a condenser in series.

For maximum efficiency, the spark gap circuit (closed oscillation circuit) must be accurately tuned to resonance with the aerial circuit.

DESCRIPTION OF THE DIAGRAM

In figure 89 the open oscillation circuit comprises the aerial A, the aerial tuning inductance L-3, the secondary winding of the oscillation transformer L-2, the short wave condenser C-3, and the earth connection G.

The closed oscillation circuit comprises the spark gap S-G, the high voltage condensers C-1 and C-2, and the primary winding of the oscillation transformer L-1.

OPERATION

If the open and closed circuits have been tuned to the standard waves of 300 and 600 meters, the procedure for changing from one wave length to the other is as follows:

Assume that the two circuits are set to radiate a wave of 600 meters, then to reduce the radiated wave to 300 meters proceed as follows:

(1) Cut out turns at the coil L-3;
(2) Open switch S-1 on the short wave condenser;
(3) Cut out turns in the primary winding L-1.

In special cases it may be necessary to insert a different number of turns at the winding L-2 for the two waves, and also, if the condensers C-1 and C-2 have capacity in excess of that required for a certain wave length, the capacity must be reduced to a value commensurate with the required wave length.

SPECIAL REMARKS

(1) The open and closed circuits may be tuned to resonance as follows: By means of a wavemeter, tune the closed circuit to one of the standard wave lengths. Then connect a hot-wire ammeter in series with the open circuit. Cut in or out turns at L-2 and L-3 until the hot-wire ammeter gives a maximum reading. The two circuits now oscillate in electrical resonance, and it is under this adjustment only, that a maximum amount of energy will be induced in the open circuit.

QUES.—To what value in practice can the natural wave length of a transmitting aerial be increased?

ANS.—In general, it will hinder the efficiency of the transmitter to raise the wave length of an aerial by more than four times its natural length. The resistance of the added inductance at values in excess of this will occasion energy losses.

QUES.—What precaution must be taken if the capacity of the closed circuit condenser must be reduced for the 300-meter wave?

ANS.—In general, in order to prevent arcing at the spark gap either the voltage of the transformer must be reduced or a reactance coil be inserted in series with the primary winding.

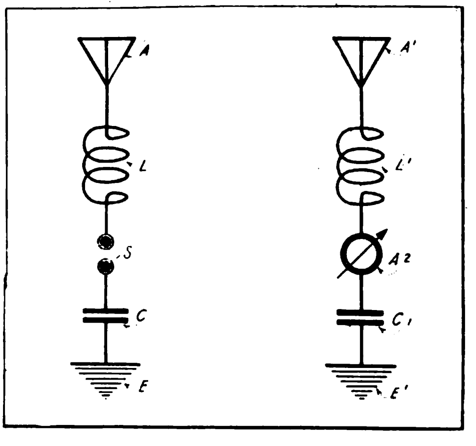


Figure 90

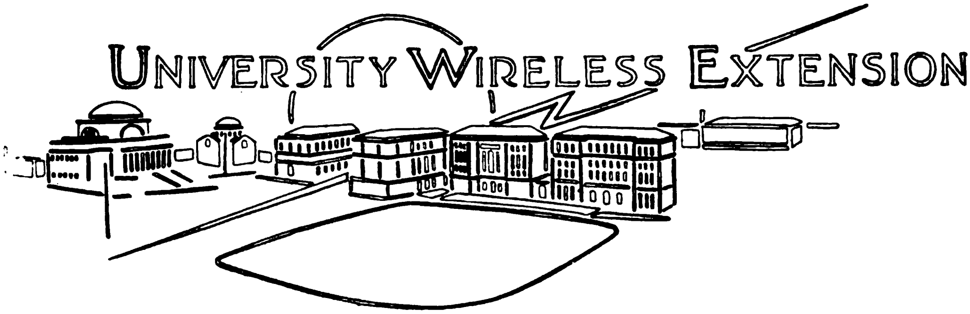
Showing how the aerial of a wireless receiving station may be tuned to resonance with the transmitting aerial. Assume that aerials A and A¹ are identical in every respect, i. e., that they possess same values of inductance and capacity throughout. Similarly, assume the coils L and L¹ possess identical values of inductance. Assume further that L and L¹ are cut out of the circuit. Then if aerial A, is set into oscillation by being charged at the spark gap S, maximum current will flow in aerial A¹ as would be indicated by the reading of the meter A². The two circuits are now in electrical resonance and the maximum transfer of energy takes place.

Now, the wave-length of the aerial A, can be increased by inserting, let us say, two turns of wire in the circuit at L. Then to establish resonance in aerial A, two turns must be added at the coil L¹. Similarly, if a condenser C of, let us say, .0005 microfarad is connected in series with the aerial A, the length of the radiated wave will be decreased and a condenser C, of similar capacity must be connected in series with the aerial A¹ to establish resonance. This, basically, is the method by which the receiving aerial is tuned to the transmitting aerial, but the student should keep in mind that "open oscillation" circuits only, are under consideration. Modern radio systems contain an **open** *and* **closed** *circuit at the transmitter, and an* **open** *and* **closed** *circuit at the receiver.*

Continuing our explanation of tuning; if the aerial A¹ is shorter than A, then if A is excited with all turns of L cut out, a few turns must be inserted in the circuit of the Aerial A¹, and L¹, to establish resonance.

Transmitting and receiving aerials of similar values of inductance and capacity are rarely encountered in wireless practice. Hence, it is necessary to provide both the transmitting aerial and the receiving aerial with a variable inductance and a variable condenser in order that the transmitter may radiate waves of different length, or that the receiver may respond to waves of different length.

(To be continued)



Radio Telephony

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ARTICLE XIII

A SYSTEM of radio telephonic control involving both an Alexanderson alternator for the direct generation of the radio frequency energy and one or more pliotrons for the modulation and control thereof is shown in Figure 163. As will be seen, the radio frequency alternator is coupled inductively to the antenna by

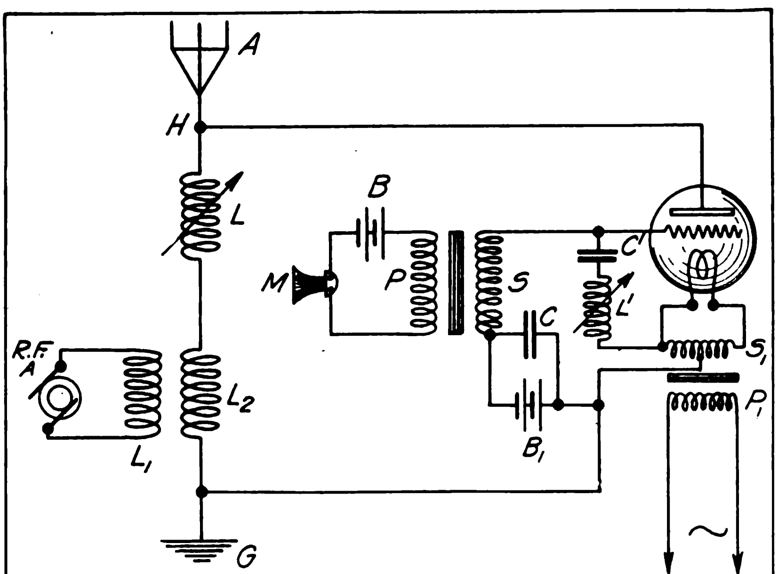

Figure 163—General Electric Company-Alexanderson-White alternator-pliotron radiophone transmitter

the coils L_1 and L_2. The antenna is tuned by the variable inductance L, and the top H of the tuning inductance is the point of highest potential within the station building. (Of course, the highest potential produced by the set is at the relatively inaccessible top of the antenna.) The filament of a large pliotron is connected to the ground, and the plate of the pliotron to the point H at the top of the tuning inductance. If the filament is heated by alternating current, the mid-point of the step-down transformer secondary whereby this is accomplished is connected to ground thus equalizing the thermionic current in all parts of the filament as much as possible (as indicated in the description of Figures 64 and 65). If the grid of the pliotron is kept at a very negative potential, the effect on the antenna energy will be practically nothing. As the grid becomes less negative, the pliotron permits increasingly more radio frequency current to pass through in rectified half cycles, thus withdrawing energy from the antenna. In other words, the output of the alternator either passes into the antenna system or into the pliotron bulb. It is found by experience that the fact that the pliotron absorption takes place only for half cycles does not affect this conclusion.

It will be noted that the grid is normally maintained at a negative potential by the battery B_1, which battery is shunted by the condenser C which acts as an audio frequency by-pass. The secondary of the audio frequency transformer S is also included in the grid circuit, and thus the grid potential is also caused to vary in accordance with the speech forms. In thus controlling the antenna energy by the pliotron, a curious difficulty arises. The impressed radio frequency plate potentials are quite high, and there is capacitive coupling between the plate and grid *within the bulb* since these metallic masses are, in effect, the parallel plates of a condenser. In consequence, there will be induced smaller, though still troublesome, radio frequency potential variations on the grid. During the positive half cycle, a positive potential is induced on the grid which may be much larger than the potential supplied to the grid from the telephone transmitter. This action, therefore, prevents control. This would render the system inoperative, but the effect is avoided by the introduction of the radio frequency short-

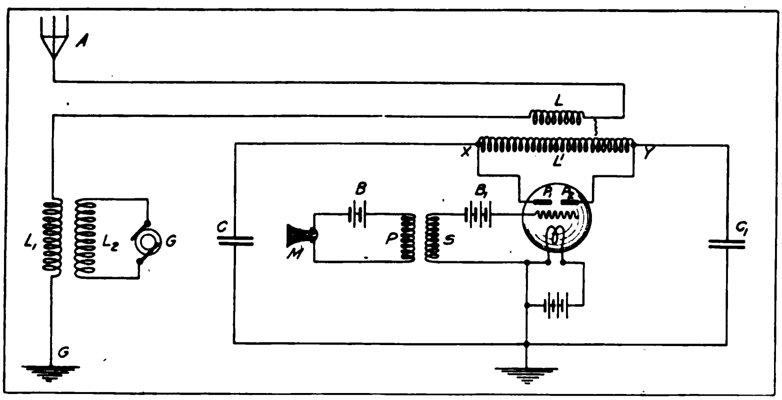

Figure 164—*General Electric Company-Alexanderson alternator-pliotron control radiophone transmitter*

circuit $L'C'$ between the grid and the filament, whereby no radio frequency potential variations can occur on the grid.

Another form of the same general type is shown in Figure 164. In this form also the control system of energy absorption by the pliotron is used, but in addition an appropriate radio frequency transformer LL' is provided. This raises the applied voltage to a value most suitable for the pliotron actually available. In other words, instead of absorbing a given amount of energy at low voltage and high current it is absorbed at high voltage and low current. Furthermore, there are provided two plates P_1 and P_2 of the pliotron so that absorption occurs during both half cycles. The actual appearance of the step-up transformer which has been used experimentally is given in Figure 165. It is an open core auto transformer consisting of a number of flat coils hung on wooden rods. One or two of the central sections are tapped to form the primary and the whole set of coils, terminating at wires X, Y constitute the secondary. Special forms of end shields designed to prevent excessive corona and break-down are mounted at the ends of these sets of coils. The exact mode of operation of this transformer is described in "Proceedings of the Institute of Radio Engineers," Volume 3, Number 2, page 138. This transformer has very low losses, so that it becomes possible to transform from 250 volts to 100,000 volts at 100,000 cycles. Under these conditions, the inductance of the transformer system was such that 2 amperes appeared at the center of the secondary winding. A study of the action of this transformer shows that if the decrement of the secondary tuned circuit be increased (by the pliotron) from its normal value of about 0.008 to about 0.8, the effective impedance of the system will increase from 125 ohms to 12,500 ohms. One unusual characteristic of this method of varying the radio frequency resistance of the antenna, by inserting therein the primary of a transformer the secondary circuit of which contains a pliotron, is that maximum secondary current naturally corresponds to minimum antenna current.

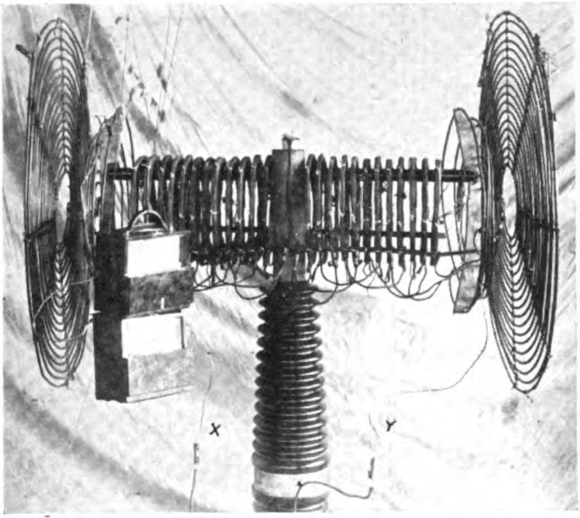

Figure 165—*Step-up transformer for radio-frequency high voltage transformation*

This system of control enabled radiophone communication between Schenectady and Pittsfield, a distance of 50 miles (80 km.), a small 2 K. W. alternator running at 90,000 cycles being used as the source.

(h) **FERROMAGNETIC CONTROL SYSTEMS.** We pass now to a highly valuable group of control systems wherein the magnetic properties of the

iron cores of inductances are utilised. They depend on the following principle. The permeability of iron is not constant; that is, the magnetic flux or induction through the iron core of an inductance is not directly proportional to the applied magnetising force (in ampere turns) but varies in the manner which was discussed in the description of Figure 96, though in connection with a different application to frequency changes. In consequence, the inductance of such a coil is dependent on the current. Starting with very small magnetisation, the permeability rapidly increases to a maximum and then slowly drops till it reaches the value unity for very high flux densities. Similarly, beginning with a small current through an iron core inductance, the inductance of the coil first rises rapidly, and then drops slowly. This point will be illustrated hereafter.

We shall consider only two radiophone systems based on this principle, since these two are the only ones in actual use at present. They are the system of the Telefunken Company, as devised by Dr. Ludwig Kühn and others, and the General Electric Company's system, as devised by Mr. E. F. W. Alexanderson.

Dr. Kühn was led to work out the first mentioned system by his failure in 1912 to control directly approximately 7 kilowatts of radio frequency energy by 72 microphones! The first circuit devised by him is shown in Figure 166. Here circuit 2 contains the radio frequency alternator G and the primary P of an ordinary transformer. We shall call the current in this circuit i_1. The next

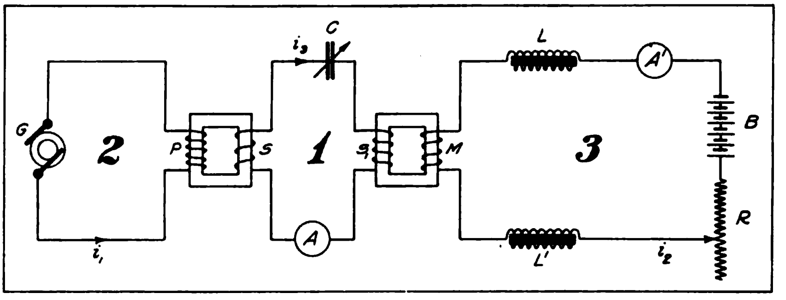

Figure 166—Control of radio frequency current in resonant circuit by variation of magnetisation of iron core of inductance

circuit, 1, contains the secondary S of the same transformer, an iron core inductance S_1, a tuning condenser C, and the ammeter A. In this circuit we have the current i_3. Circuit 3 contains the battery B, a variable resistance R, the ammeter A', two choke coils L and L' to prevent radio frequency currents flowing in this circuit by induction from S_1 to M, and the magnetising coil M. If circuit 1 be tuned to resonance and then circuit 3 be closed, the inductance of S_1 will be changed because of the change in permeability of the iron core. In consequence, the current in circuit 1 will drop as the direct current in circuit 3 is increased. Conversely, we might arrange to have full resonance current in circuit 1 with a moderate direct current flowing through M, and in this case diminishing (or increasing) the direct current would cause the alternating current

in circuit 1 to drop. This, then, is a system whereby the radio frequency current in circuit 1 may be caused to follow variations in the current in circuit 3.

The control characteristic of a somewhat improved system of this type, shown in Figure 169 below, is given in Figure 167. Vertically is plotted the radio frequency current in the antenna and horizontally the magnetising force (i. e., the product of amperes and turns). It will be seen that the control is linear between point *A* (corresponding to 10 amperes antenna current) and *C* (corresponding to 40 amperes). A change in ampere turns of 1,100-600 or 500 is necessary to effect this change in antenna current. The reason why the curve of Figure 167 bends at *C* is shown in Figure 168, which is the magnetisation curve of the iron core of the controlling inductance. It will be seen that the control must be much more effective for magnetising currents lying between the value *OA* and *OB* than for values lying between *OB* and *OC*, since the difference between *BE* and *AD* is considerably greater than the difference between *CF* and *BE*.

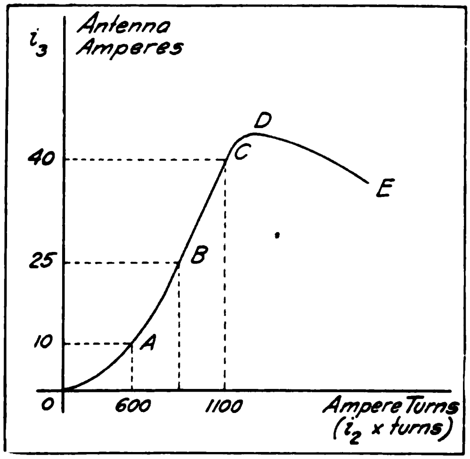

Figure 167—Control characteristic of resonant circuit containing iron core inductance of variable magnetisation

A control system of the type shown in Figure 166 will be most effective under the following conditions. (By effectiveness is meant a maximum change in the alternating current i_3 for a given change in the direct current i_2.)

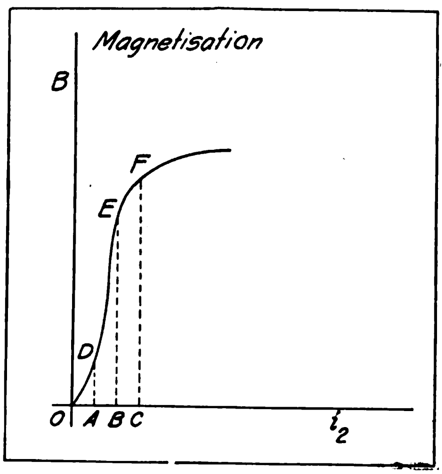

Figure 168—Iron magnetisation curve

1. When a given amount of change of direct current energy in circuit 3 causes the greatest possible change in the inductance of S_1;
2. When the damping of circuit 1 is a minimum, so as to give sharp resonance phenomena;
3. When the couplings between the various circuits are suitably adjusted;
4. When the ratio of the continually present inductance in the circuit 1 to the variable component of inductance in that circuit is a minimum.

Some of these requirements are incompatible with each other. For example, requirements 2 and 4 may easily conflict. A rational compromise must then be effected. As far as requirement 2 is concerned, this will require the use of very thin sheets of special iron as the core of the inductance S_1. In fact, sheets 0.001 inch (0.02 mm.) to 0.002 inch (0.04 mm.) are recommended for this use.

An improvement on the system of control shown in Figure 166 is given in Figure 169. It will be seen that in this case the magnetising coil *M* controls the

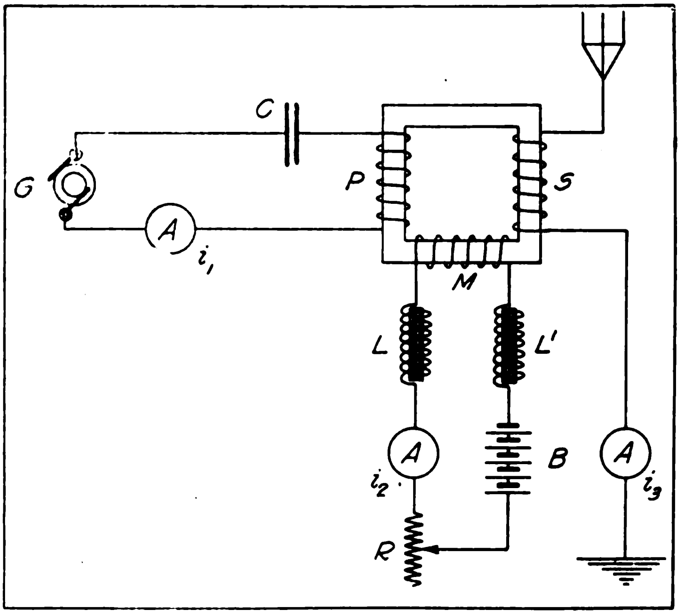

Figure 169—Telefunken Company-Kühn system of antenna current control

inductance P of the radio frequency alternator circuit and also the inductance S in the antenna circuit. Consequently both circuits may be detuned and the resulting change in antenna current for a given change in magnetising current i_2 will be considerably enhanced.

A further study of Figure 167 will indicate that the portion AC of the control characteristic should be as long as possible, and as straight and steep as possible. It was feared at first that working with iron core inductances in the radio frequency circuits, hysteresis effects might distort the speech so as to make it unrecognisable. Experiment, which is an unfailing criterion in such matters, demonstrated conclusively that this fear was groundless. Care must be taken, however, not to exceed the limits of antenna current imposed by the straight line portion of the control characteristic. For an actual characteristic given in Figure 167, the change in antenna energy between 10 amperes and 40 amperes would be 5.4 K.W. with the antenna used. In use for radio telephony, a somewhat more limited range of control was used.

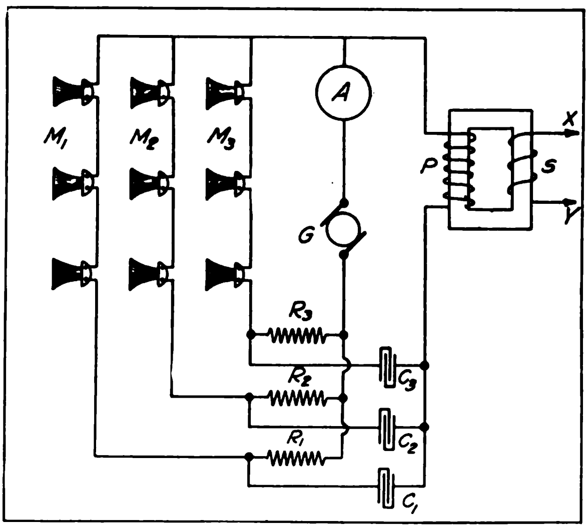

Figure 170—Telefunken Company-Kühn system for utilising microphones in parallel on direct current

In order to secure the necessary control speech current, Dr. Kühn devised the series-multiple arrangement of microphones shown in Figure 170. This is considered at this point instead of under "Microphone Control Systems" because no radio frequency energy is supposed to pass through the microphones and they control only indirectly through a ferromagnetic inductance. Each of the microphone banks M_1, M_2, M_3 is fed from the same generator G and

through its individual large resistance R_1, R_2, R_3. Across each microphone is shunted the primary P of the telephone current step-down transformer and the corresponding one of the three condensers C_1, C_2, C_3. The output is taken from XY. The action is simple. Whenever the microphone resistance increases, the current through its series resistance remains nearly constant but the current through it diminishes. The excess current tends to find its way through P and the corresponding condenser. This arrangement of microphones is easily seen to be stable. The telephone transformer PS must be carefully designed. In practice it is a 10-to-1 step-down transformer with a total iron path of about 13 cm. (5 inches). The primary and secondary volt-amperes are nearly equal, the leakage, resistance, iron losses, and magnetising current being all reduced to a minimum.

It will be noticed from Figure 169 that there is a marked tendency to induce radio frequency currents in the magnetising circuit including M, since M is, in effect, the secondary of a transformer of which P is the primary. Drastic means must be taken to avoid this because of the damage to the battery and microphones which would be done and the loss of output energy resulting. In Figure 169 ordinary iron core choke coils are indicated as the means whereby the radio frequency currents are choked off, but this means would almost always be entirely insufficient. The distributed capacity of such a coil would cause it to interpose, but little impedance to the radio frequency currents, in general. A more usual means is by the use of the loop circuit shown in the left of Figure 171. As is well known, the reactance of such a loop measured between the points U and V becomes infinite at the frequency for which the loop is resonant, provided there are no losses in L and C. Even if there are small losses in L and C, the impedance will become very high. An improved method whereby unusually high impedances can be secured by the coils used in practice is shown in the right hand portion of Figure 171. Here L_1 and L_2 are two coils wound in opposite directions on the same core (not of iron). L' and L'' are small inductances widely separated from each other. L_3 and L_4 constitute a double coil similar to L_1 and L_2. The tuning condenser C' is inserted as shown. For the audio frequency telephone currents, L_1 and L_2 form a system of very low inductance as do L_3 and L_4. In fact, the inductance between U and V for telephone currents is only 20 microhenrys in one practical instance. On the other hand, for the radio frequency currents the impedance is extremely high.

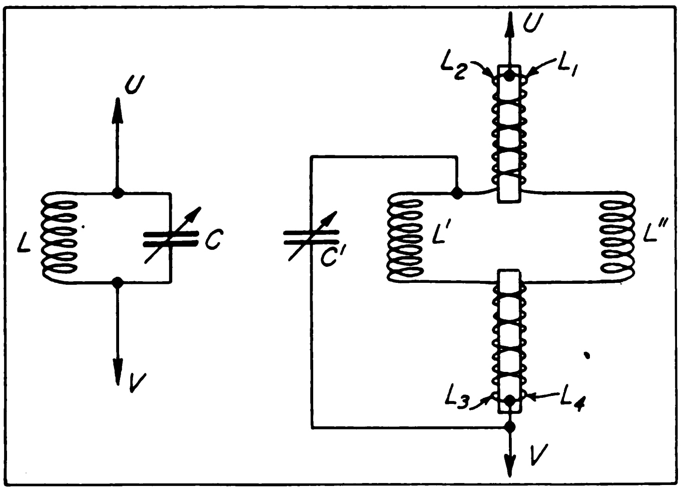

Figure 171—*Ordinary and Telefunken Company-Kühn radio frequency choke systems*

The latest and most improved pattern of these radiophone sets is shown in outline in Figure 172. As will be seen, the generator G of radio frequency energy is placed in a tuned circuit including C and the primaries P_1 and P_2 of the fre-

quency changers. (A description of these frequency changers has already been given in connection with Figures 96 through 100.) The secondaries S_1 and S_2 of the frequency changers are in the antenna circuit in series with a necessary tuning inductance. The direct current generator G_1, is arranged to supply the direct current magnetisation of the frequency changers by the coils M_1 and M_2. The two gaps in the circuit of this generator at UV are supposed to be filled with choke systems such as those of Figure 171, the lettering corresponding. The telephone control current produces *changes* in the otherwise constant magnetisation of the frequency changer cores in passing through the coils M' and M''.

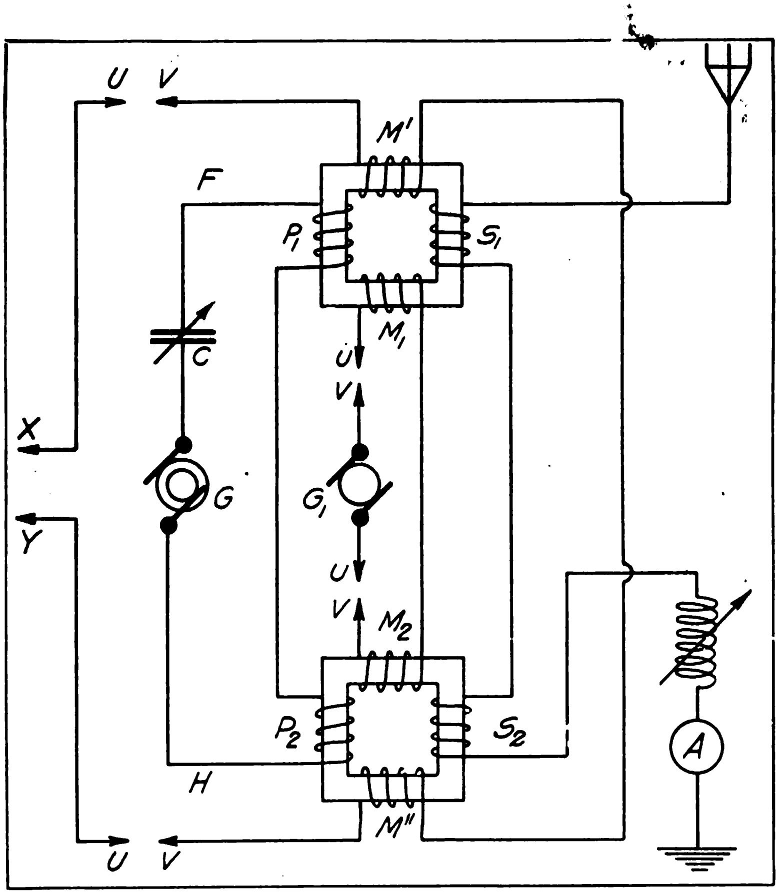

Figure 172—*Telefunken Company-Kühn radiophone transmitter,* 1913

The telephone currents originate in the gap XY which corresponds to the terminals XY of Figure 170, the remainder of the microphone system being omitted from Figure 172 for the sake of simplicity. For the same reason, the choke systems at points UV in the telephone control circuit are only indicated. It will be noted that the system here shown differs from the simpler system of Figure 169 not only in the use of the frequency changers but also in the separate constant direct current magnetisation and separate telephone control current magnetisation. Instead of having only one set of frequency changers, the terminals FH may themselves be the output terminals of one or more frequency changers these being placed where the generator G is indicated.

An actual radiophone set of this type is shown in Figure 173. This set is supposed to be run from 110 volt direct current mains. A motor drives the 10 K. W., 10,000 cycle alternator, which is similar to that shown and explained

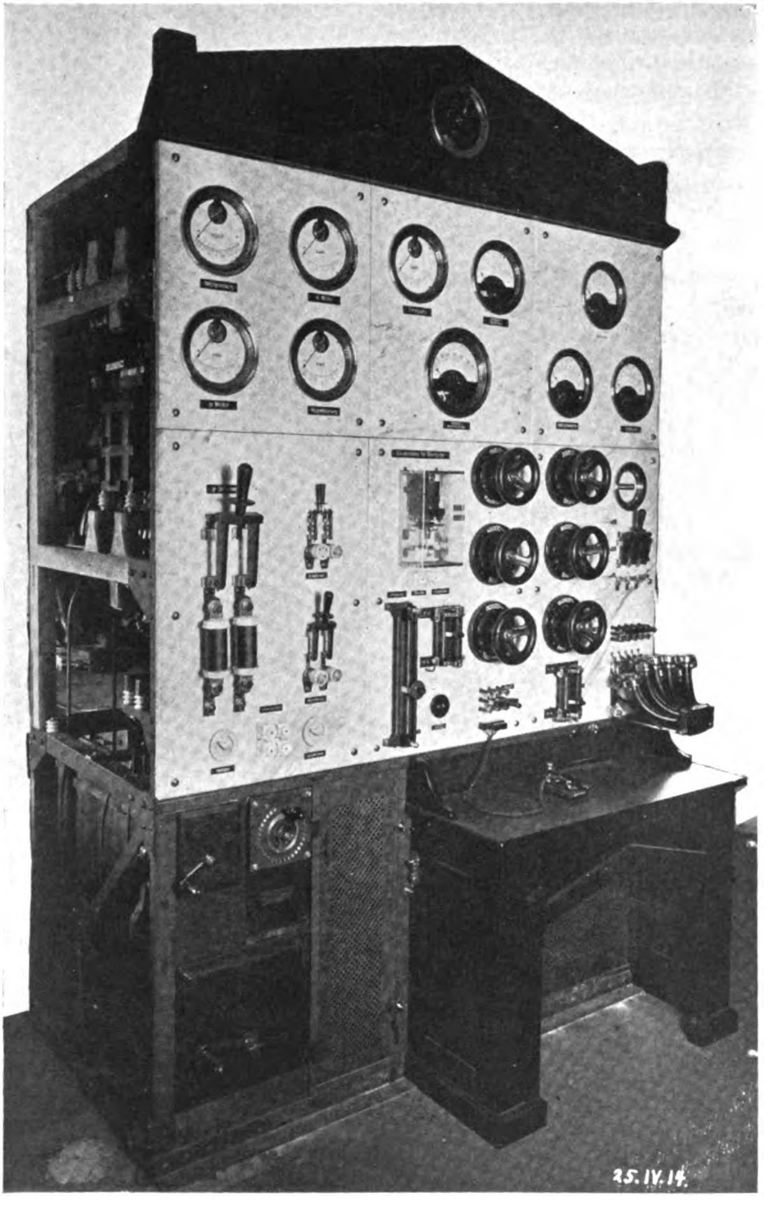

Figure 173—Telefunken Company 1 K. W. alternator-frequency doubler radiophone transmitter

in connection with Figures 101 and 102. The frequency may be raised in four steps to 160,000 cycles corresponding to 1,880 meters wave-length. In the middle of the top crown panel is a control stroboscope for watching the telephone control. This device is a small neon or carbon dioxid vacuum tube rapidly rotated by a small motor. It is connected through a small capacity to a high potential point of the antenna system, and when there is subtained radiation, a uniform circular band of light caused by the rotating tube indicates this fact. If a musical sound affects the microphone transmitter, the circular band of light is broken into narrow radial bands, and the relative brightness of the center of the bands and the darkness of the middle of the space between them indicates very roughly the completeness of the modulation. However, such instruments are far from quantitative, being at best rough indicators. The top row of instruments are respectively for the direct current supply voltage, the current supplied a special small motor, the excitation (field) direct current, the 80,000 cycle telegraph control key circuit, and a 0-to-40 ampere antenna ammeter. The second row of instruments are the large motor ammeter, the "magnetising" current, an 80 ampere ammeter for the 10,000 cycle output circuit, a 10 ampere ammeter for indicating the alternating current from the microphone transformer (corresponding to *XY* of Figure 170), and the antenna current ammeter for telephony. The lower left panel carries the large driving motor switch, the magnetising current switch, and control switches and fuses for the stroboscope and the ventilating fan motor. The center lower panel carries the key relay (for telegraphy) a field rheostat, the frequency regulating device of the musical tone producer for ordinary telegraphy (simulating a spark station), and the wheels which control the tuning inductances (variometers) of the 10,000 cycle circuit, the 40,000 cycle circuit, and the 80,000 cycle key circuit. On the right hand lower panel are the control wheels of the inductances in the 20,000, 80,000, and 160,000 cycle (antenna) circuits, the frequency meter for musical tone telegraphy, and 8 or 10 microphones suitably arranged. The desk carries the telegraph key and the bottom panel to its left the motor starters and regulators. The entire outfit can put about 6 kilowatts into the antenna at 1,900 meters for telegraphy and several kilowatts for telephony. Some figures given by Dr. Kühn indicate that a microphone output of about 4 watts (or 20 volt-amperes), corresponding to a control alternating current of 8 amperes through the 30 turns of the 40 microhenry control windings on the final transformers, suffices to control several kilowatts, the energy amplification being as great as 1,000.

With a set similar to that shown, using the Nauen antenna and at a wave-length near 5,000 meters, speech was transmitted from Berlin to Vienna, a distance of 340 miles (550 km.), the received words having an audibility of 100. Professor Kann, listening at Vienna, stated that there was unusually heavy atmospheric disturbances. The speech was clear but the vowels were emphasized while the consonants seemed sometimes to be almost missing. On the other hand, singing was faultlessly transmitted. How far these effects were due to the heavy strays and how far to iron distortion of the speech forms is not stated.

We consider next a further development of the ferro magnetic control systems, namely Mr. Alexanderson's magnetic amplifier as designed for the General Electric Company. Prior to considering this device, the parent idea from which it sprang will be given. This was a so-called "telephone relay." It was a moderately high frequency alternator of the inductor type the field of which was varied by the speech current. In consequence the output of the machine was similarly modulated. The rotor of the machine is shown in Figure 174. The iron teeth had to be laminated because of the variations in the field produced by the speech current. This was a serious limitation of the machine. The stator of the machine is similarly shown in Figure 175. The zig-zag winding of the alternator around the teeth is clearly visible. Underneath this winding are field windings. To avoid the limitation mentioned above, the modern

magnetic amplifier was invented, this being a device which has practically the same effect, when placed across the terminals of a radio frequency alternator, as would speech variation of the field thereof.

Let us consider first the operating characteristics of an Alexanderson radio frequency alternator, namely the 50 K. W., 50,000 cycle machine shown in Figure 113. These characteristics are shown in Figures 176. It will be seen that if 50 ohms of external resistance are shunted across the machine terminals, the current (at the point W) will be 17 amperes. As this load resistance is diminished, the current rises along the dashed curve to the point Q. This corre-

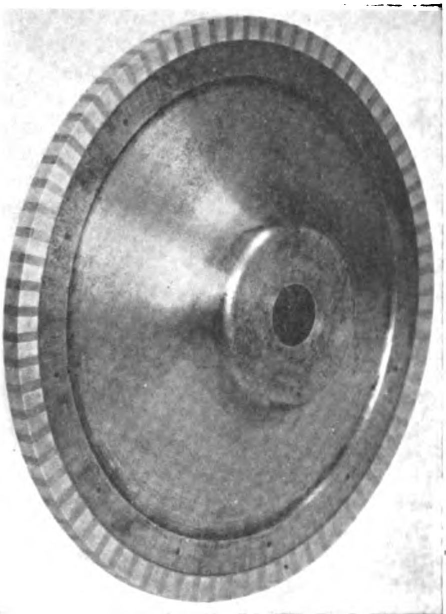

Figure 174—General Electric Company-Alexanderson telephone control relay rotor

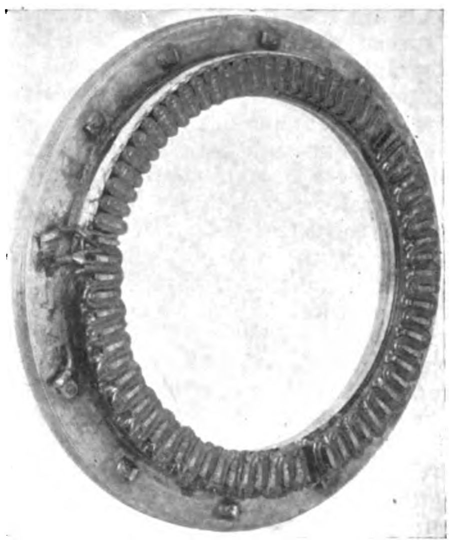

Figure 175—General Electric Company-Alexanderson telephone control relay stator (field and armature)

sponds to zero resistance, across the alternator and to a current flow of 63 amperes. This current, since the load is a pure resistance, is in phase with the voltage (neglecting machine impedance), and the curve has been repeated symmetrically to the left of the current axis by the curve QX. If various reactances (in the form of resistance-free inductance) are placed across the terminals of the machine, the curve QV is obtained for the relation between current and external reactance in ohms. Thus the point V corresponds to 50 ohms reactance or 0.00016 henry at 50,000 cycles. The current in this case lags behind the electromotive force since the load is inductive. If 50 ohms of capacity reactance, which corresponds to 0.064 microfarad at 50,000 cycles, and is indicated at the point U, be placed across the machine, a current of 24 amperes is obtained. As the external capacitive reactance is diminished, the current increases, reaching a maximum of 71 amperes at 8 ohms corresponding to 0.40 microfarad at 50,000 cycles. On leaving the point P of maximum current, with diminishing external reactance and corresponding external capacity load, the curve drops again to the point Q. In the portion QPU of the curve, the current leads the voltage since the load is capacitive. It will be seen that the curve $UPQV$ is nothing more than the resonance curve of the system made up of the alternator armature and the

external load. Since the capacity reactance for resonance is 8 ohms, the inductive reactance of the alternator armature must have the same numerical value. Con-

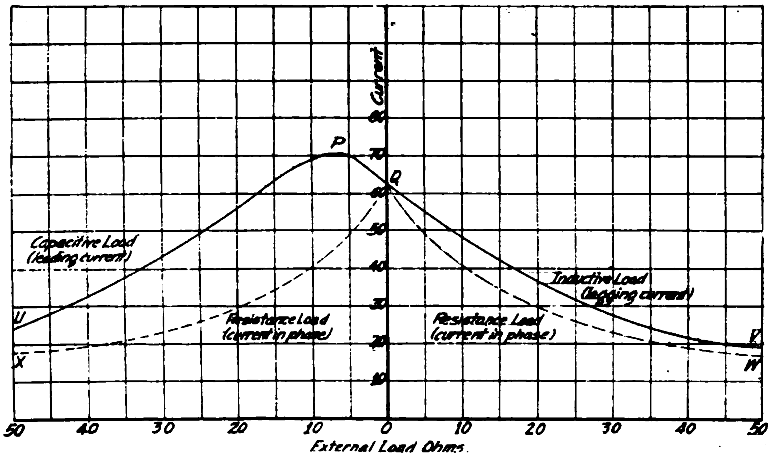

Figure 176—Load characteristics of 50 K.W., 50,000 cycle Alexanderson alternator

sequently the inductance of the armature must be approximately 26 microhenrys at 50,000 cycles, an interestingly low value.

The same material is plotted in another fashion (based on the curves given by Mr. Alexanderson in an earlier publication) in Figure 177. The curves given differ from those of Figure 176 only in that alternator terminal volts and load current are plotted instead of external impedance and load current. It may be noted that the 0 per cent. power factor curve is that of a *pure* inductive or capacitive load; that is, one which is resistance-free. In the same way, the 100 per cent. power factor resistance curves are with a load consisting of *nothing but resistance.* While not quite so clearly visible, the resonance phenomenon is indicated here also.

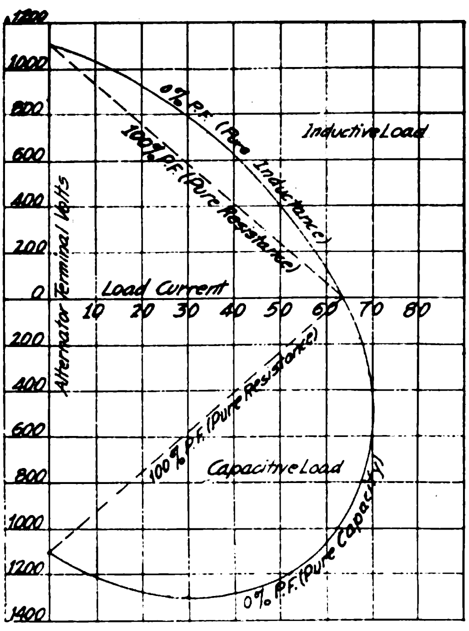

Figure 177—Load characteristics of 50 K.W., 50,000 cycle Alexanderson alternator

The general arrangement of the magnetic amplifier in its simplest form are represented in Figure 178. The nature of the iron structure is sufficiently indicated. Coils L_1 and L_2 are wound over the two middle cores, connected in parallel, and the combination shunted across the radio frequency alternator *A.* (Coils L_1 and L_2 are placed in parallel rather than in series since theory and experiment agree in predicting a more effective control by such connection.) It will thus be seen that the iron core inductance L_1 L_2 is placed across the alternator terminals. If this inductance is varied by any means, the right hand curve of Figure 176 will indicate the

current variation through the inductance. Consequently the antenna current will also vary in the opposite sense, and a marked degree of antenna current control would be thus obtained. The mode of varying the inductance of coils L_1 and L_2 is also shown clearly in Figure 178. It is by means of the coil L_3 through which passes a direct current from the battery B which current can be suitably varied by the control resistance R. It will be seen that L_3 is wound over the cores of both L_1 and L_2 and thus there will be therein no radio frequency induction from the latter. This is important, and constitutes a marked advantage of Mr. Alexanderson's magnetic amplifier over the device used by the Telefunken Company and shown in Figure 172. The actual appearance of the amplifier is given by Figure 179. The magnetising control coils L_3 are indicated as in Figure 178. The two sets of coils corresponding to L_1 and L_2 are also indicated. The coils L_1 are partly hidden by the cross piece. It may be mentioned that a number of further designs of more advanced character have been adopted recently for the magnetic circuits of the amplifier, but the principle remains unchanged.

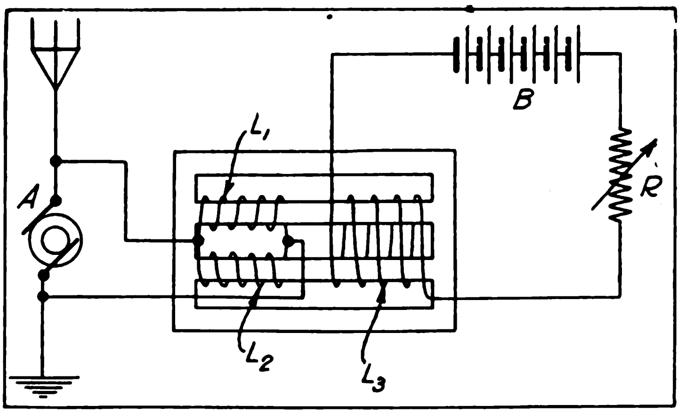

Figure 178—General Electric Company-Alexanderson magnetic amplifier (shunt connected to alternator, multiple connection of coils)

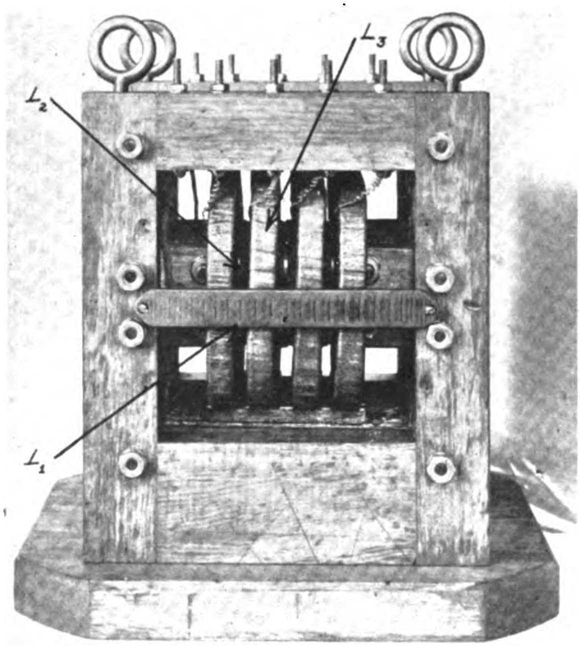

Figure 179—General Electric Company-Alexanderson "magnetic amplifier" radiophone control

The actual behavior of the amplifier is well represented by Figure 180. This shows the impedance of the amplifier, expressed in ohms, plotted against the radio frequency current passing through it for various direct currents through the magnetising coils L_3. It will be seen that for no magnetisation (curve ABC) the impedance varies from 32 to 70 ohms between 60 amperes of radio frequency current and 20 amperes. With 0.7 ampere d. c. magnetisation, the variation is somewhat in the opposite sense, namely between 27 ohms and 15 ohms for the variation of radio frequency current between 60 and 10 amperes. For 2.0 amperes magnetisation

current, the impedance of the amplifier remains nearly constant around 8 ohms for the same extreme variation of radio frequency current through it. Considering the line *ADGK*, it is clear that with 60 amperes radio frequency passing through it, the amplifier impedance changes from 32 ohms to 8 ohms as the direct current magnetisation is increased from 0 to 2.0 amperes. Similarly, at 55

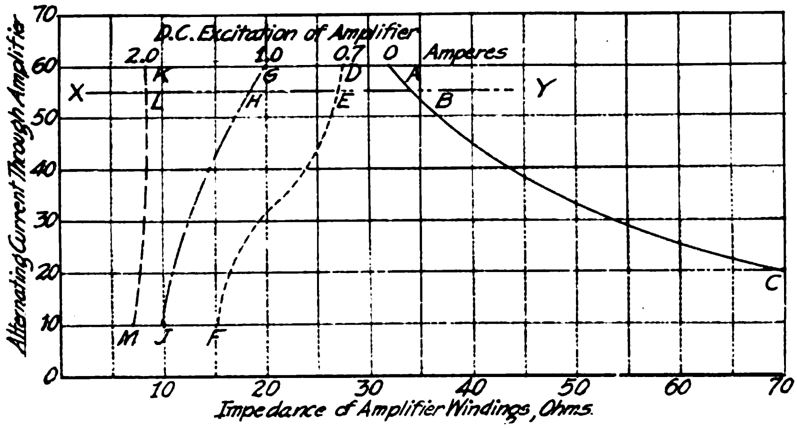

Figure 180—*Characteristics of Alexanderson magnetic amplifier*

amperes radio frequency current through the amplifier, corresponding to line *XY*, a somewhat wider variation is obtained. It is thus perfectly clear that the amplifier is a markedly effective device as a variable impedance for radio frequency currents. The same data as that represented in Figure 180 is given in different form in Figure 181, which gives the corresponding voltage-current curves of the amplifier. It will be seen that the current through the amplifier at 400 volts impressed radio frequency may be varied from 5 amperes (for no d.c. magnetisation) to 50 amperes with 2.0 amperes magnetisation. At 1,200 volts applied radio frequency, a current variation of 15 to 60 amperes (i. e., from 18 to 72 kilovolt-amperes) is obtained with a variation of the d.c. magnetisation of only 1 ampere, a full illustration of the usefulness of the device.

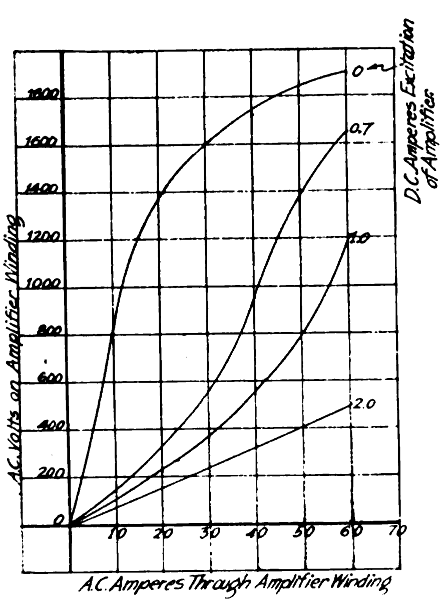

Figure 181—*Characteristics of Alexanderson magnetic amplifier*

In order to secure the maximum linear control and to prevent certain undesired effects, several condensers are inserted into the amplifier circuits as shown in Figure 182. The first of these is the series condenser C_1 which is placed between the high potential point of the alternator and a point leading to one side of the amplifier (through several other condensers to be considered below). The effect of the series condenser on the stability of operation of the amplifier and otherwise is illustrated in Figure 183. This curve shows the current flowing from the alternator as ordinate plotted against the external impedance in ohms. The dot-

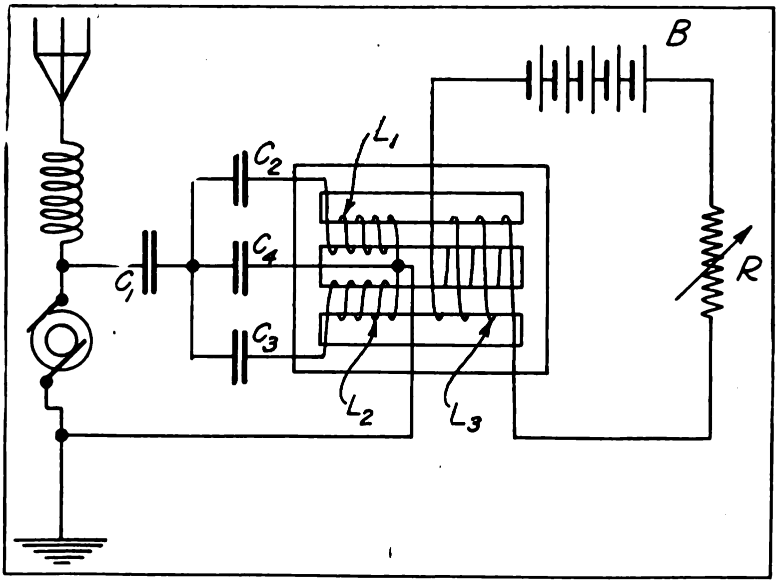

Figure 182—*General Electric Company-Alexanderson magnetic amplifier; with series, short-circuiting, and shunt condensers*

and-dash curve shows the effect of a purely inductive load and is the same as curve QV of Figure 176. The dashed curve for the amplifier alone is not far from curve ABC of Figure 180. To the left of the vertical axis is drawn the corresponding curve of the constant impedance of 8 ohms, this being a capacity of 0.33 microfarad. The curve in question is the vertical line marked 0.33 μf. Inserting such a condenser at C_1 will give the resulting curve to the right marked "amplifier + 0.33 μf." This curve represents a stable state of affairs. At the extreme left, the vertical dashed line shows the constant impedance of 48 ohms corresponding to a series condenser of 0.067 microfarad. The curve marked "amplifier + 0.067 μf." is the result of using this series condenser and has an unstable portion to the left of the vertical axis. This corresponds to an *increase* of current with an *increase* of impedance across the alternator. The

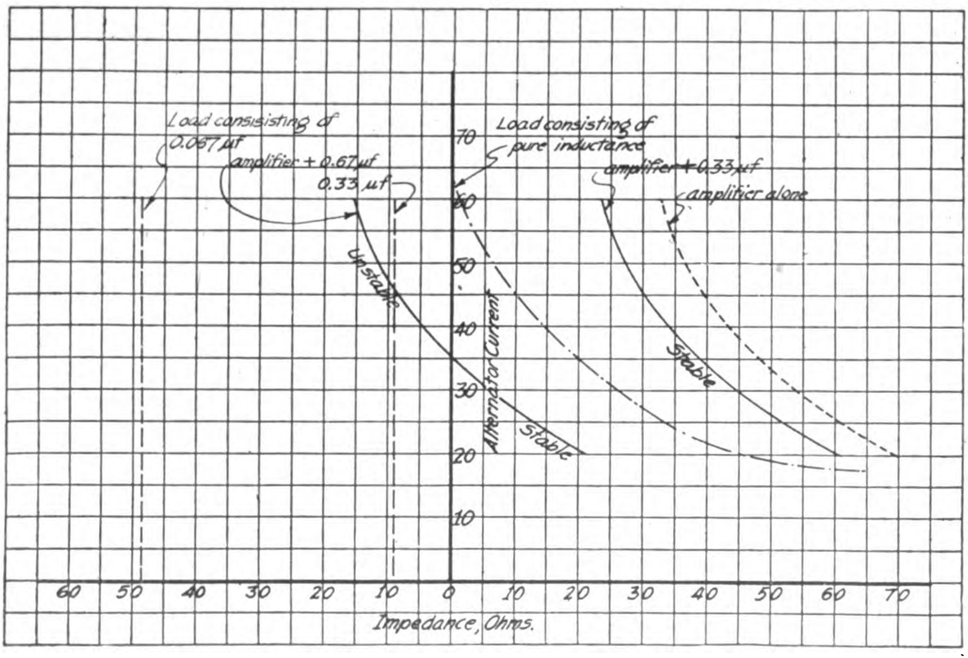

Figure 183—*Effect of series condenser on stability of magnetic amplifier*

same effect is shown in Figure 184 in different form, this Figure representing alternator terminal voltage vertically and current through the amplifier and condenser horizontally. The curve marked "amplifier + 0.33 μf." is a rising curve practically throughout, whereas the curve for the "amplifier + 0.125 μf." shows a falling portion corresponding to *increasing* current with *diminishing* voltage. This is what we have called a condition of "negative resistance" such as is experienced, for example, in the Poulsen arc. Accordingly, this unstable region is unusable and may lead to self-excited oscillations in the amplifier system, which is a normally undesirable condition.

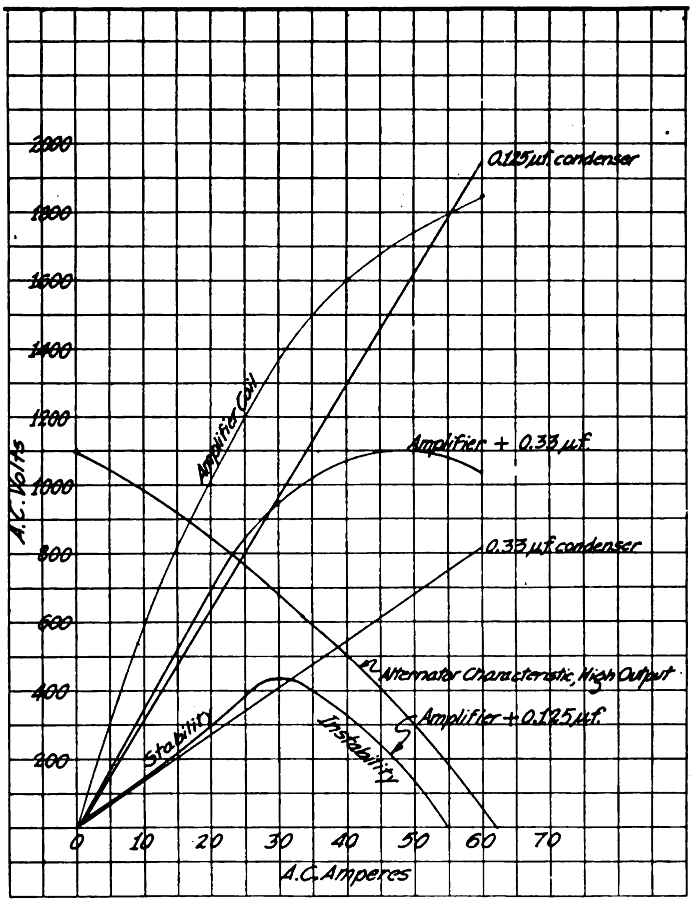

Figure 184—Effect of series condenser on stability of magnetic amplifier

The effect of the series condenser C_1 in Figure 182 is to give a great increase in the sensitiveness of the system and also to give a linear control characteristic. The control characteristics for several values of the series condenser are shown in Figure 185, which should be carefully compared with Figures 115 through 117. Curve *A* of Figure 185 shows the relation between *antenna current* in the arrangement of Figure 182 and the d.c. *amperes in the magnettising coil* of the amplifier (L_3 in Figure 182). It is the real control characteristic of the system when used for radio telegraphy and telephony. Curve *B*, obtained with a series condenser of 0.33 microfarad, shows practically complete and linear modulation except for excessive control to the left of the point *B*, this corresponding to greater amplifier magnetising currents than about 2.8 amperes. To the left of this point the control reverses as indicated in Figure 5 which corresponds to this case. Between *Y* and *Z* of that figure we are working on portion *BD* of curve *B* of Figure 185, but between *X* and *Y* of that figure we are working on the reversed portion of curve *B* of Figure 185. It need hardly be said that in practice this condition can be and is easily avoided. A smaller series condenser of 0.125 microfarad gives control characteristic *C* of Figure 185. This is a steeper control than those of the preceding cases, but it is incomplete and therefore not chosen. Some study will convince the reader that these control curves are closely related to inverted resonance curves in a system having

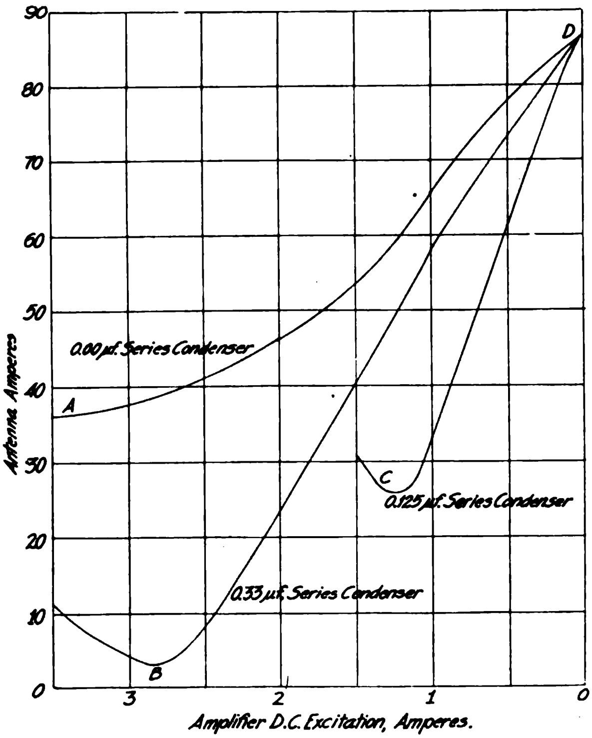

Figure 185—*Control characteristics of magnetic amplifier*

moderate effective resistance and iron losses.

The second condenser considered, namely, C_4, in Figure 182, is known as the shunt condenser. Its function, according to Mr. Alexanderson, is to cause the amplifier to take a leading, instead of a lagging current at low excitations and to increase the sensitiveness of the arrangement. According to Mr. Louis Cohen, it may rather be treated as forming with the amplifier a loop circuit the impedance and effective resistance of which change very markedly near a resonant frequency.

The third condenser (actually the two condensers C_2 and C_3) is known as the short-circuiting condenser. It will be noticed that there is a closed circuit $L_1C_2C_3L_2$ in which audio frequency currents may be induced if telephonic currents flow in the control winding L_3. These would be short-

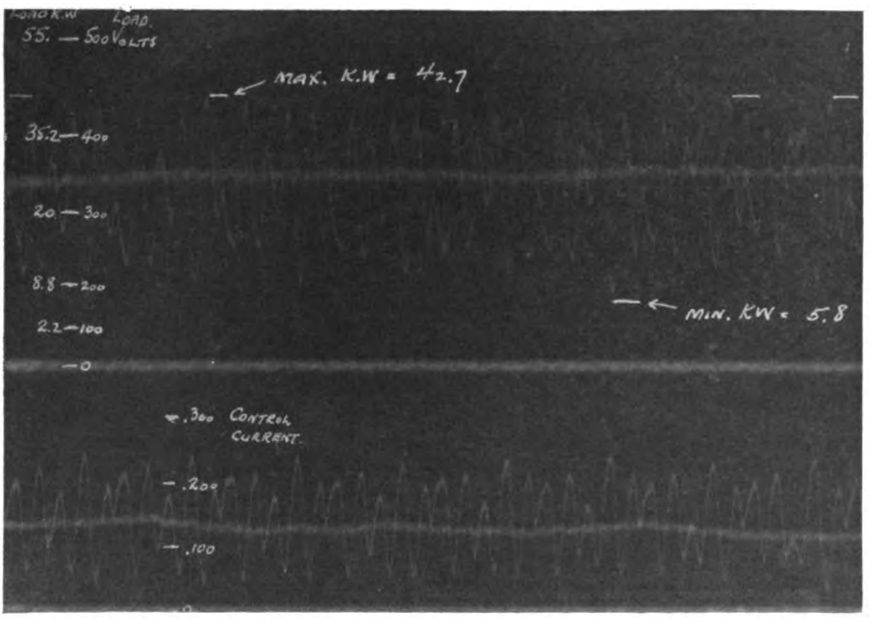

Figure 186—*Oscillograms showing controlling telephone current and controlled antenna output of General Electric Company-Alexanderson* 50 *K. W. alternator and magnetic amplifier*

circuited except for the two condensers just mentioned, and the control would become ineffective. The condensers C_2 and C_3 are so chosen that their audio frequency reactance is very high while their radio frequency reactance is quite low. In this way the radio frequency currents may still flow practically undeterred through the amplifier coils while the audio frequency currents are almost entirely prevented from doing so.

The combination of these various condensers gives a high degree of control. Experiment shows that the amplification, defined as the radio of (maximum antenna kilowatts minus minimum antenna kilowatts) divided by (effective kilovolt-amperes in the control circuit), varies from 100-to-1 to as much as 350-to-1. This is under the linear conditions necessary for control in telephony. The perfection of the control is well illustrated in Figure 186. The lower oscillogram shows the control current in L_3 in Figure 182, while the upper curve shows the antenna kilowatts. It will be seen that a variation of control current of 0.2 ampere changes the antenna kilowatts from 5.8 to 42.7, a variation of nearly 37 kilowatts! The Author believes this to be the largest amount of radio frequency (or other) energy ever controlled by a telephone transmitter. It will be noted that the antenna kilowatt curve is inverted relative to the control current curve, the peaks in one corresponding to the crests in the other. This is the result of the control characteristic of Figure 185, which shows that *large* antenna currents correspond to *small* control currents and vica versa.

This is the thirteenth of a series of articles on "Radio Telephony," by Dr. Alfred N. Goldsmith. In the fourteenth article, to be published in the February issue, the subjects discussed by Dr. Goldsmith include radiating systems, receiving systems, detector and amplifier types, selectivity in reception, interference with radiophone reception, telephone receivers, and receiving apparatus.

The Red Cross Asks for Old Tracing Cloth

AMERICAN manufacturers, architects, and all draftsmen are called upon to render an important service to their country. When the workman has finished with the piece of cotton or linen cloth used in his trade, it is flung aside to be destroyed. The Red Cross is asking now for that discarded material. All over the country thousands of women are earnestly engaged in the manufacture of surgical dressings to be used in the hospitals for our wounded soldiers and sailors. The problem of getting enough white goods for this work is enormous. As long as the war goes on the work must go on if we are to live up to the humanitarian ideals typified to the world today by the Red Cross.

Two kinds of cloth are available—draftsman's tracing cloth and old linen and cotton articles to be donated from private households and, often in large quantities, from hotels. These can be easily collected and handled by the modern laundries, which have now been called upon to perform this work for the Red Cross. With their facilities for collecting, washing, sterilizing and delivering to the local chapters, the laundries are in a position to perform an invaluable service and the least that other trades can do, is to help them in every way. If any manufacturer, architect, or draftsman will go to the slight trouble of calling up either the local Laundry Owners Association or one of the large laundries of his city, he will find them only too glad to send for such cloth as he can give them.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Damped and Undamped Wave Receiver for Long and Short Waves

In anticipation of the "grand opening" to which all good amateurs are looking forward, I have designed and built an oscillator cabinet for the reception of long and short damped and undamped waves, a description of which may prove of interest to your readers.

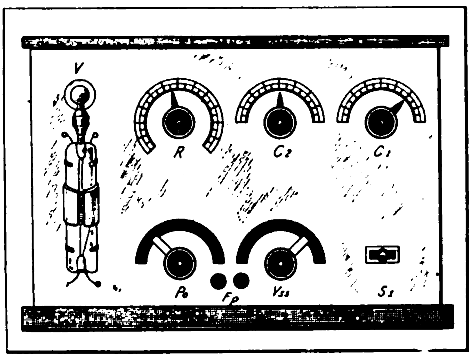

Figure 1—1st prize article

The apparatus I have devised is shown in Figures 1 and 2, Figure 1 showing the general external appearance of the cabinet and Figure 2 the complete circuit diagram. I have also furnished in the table, Figure 3, complete data for the various coils employed in the open and closed oscillation circuits. The general idea of my design was to mount compactly in one cabinet all apparatus required for a complete receiver of the type mentioned, with the exception of the tuning coils which are mounted separately.

The following instruments are mounted on the finished cabinet and an explanation of the lettered parts given follows:

B, high voltage battery;
C-1, Secondary shunt condenser, .001 microfarad capacity;
C-2, Plate circuit condenser, .001 microfarad capacity;
C-3, Telephone condenser, .001 microfarad capacity;
C-4, Grid condenser, .0001 microfarad capacity;
V, Three-element vacuum valve;
R, Filament rheostat;
Po, Potentiometer for high voltage battery;
Vss, Variable static shunt;
Fp, Telephone binding posts;
S-1, Changeover switch (secondary circuits).

The symbols used in the diagram of connections (Figure 2) are explained as follows:

A is the battery for lighting the filament;
S-2 the switch for changing the aerial and ground connections from a long to a short wave in the primary circuits and vice versa;
L is the inductance.

The variable static shunt shown prevents the accumulation of extra high potential on the grid condenser. It was made by marking heavily with a pencil on a thin piece of bakelite of the shape indicated at Vss, Figure 1. A piece of brass moves over the pencil mark thus providing a leak of variable resistance.

The changeover switch, S-1, was made by connecting four two-point switches with a piece of bakelite to which a composition knob is attached. This knob is screwed on a short bolt

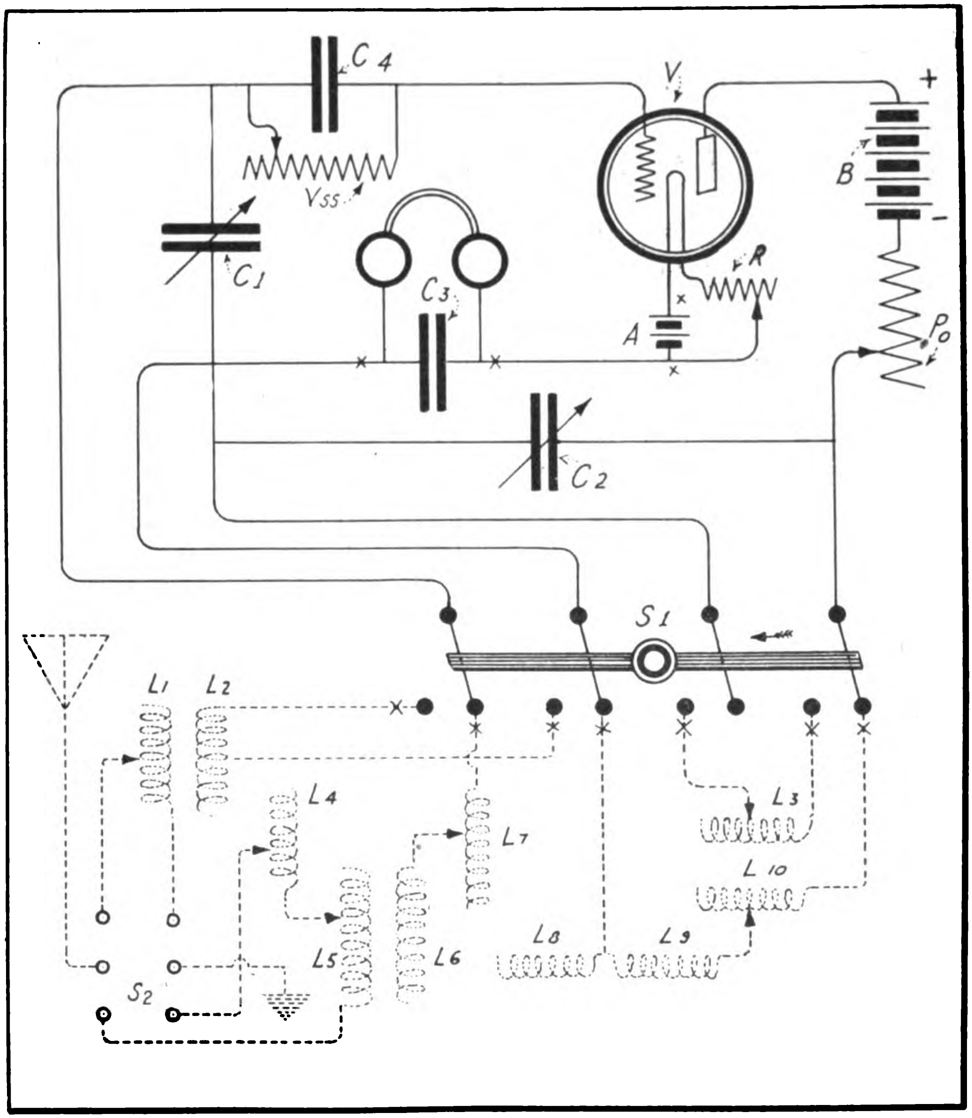

Figure 2—1st prize article

which protrudes through the cabinet in a slot cut for it.

The points marked X are connected to binding posts which, with the exception of the telephone posts, are mounted at the rear of the cabinet.

No connection is made with the switch contact marked with an arrow.

The material required for the cabinet is listed as follows:

Top, 19 inches by 8 inches by 1/4 inch; ends, 8½ inches by 7 inches by ½ inch; base, 19 inches by 8 inches by ½ inch; sides, 18 inches by 8½ inches by ¼ inch.

Quarter sawed oak which has been waxed and stained should be employed.

In addition to acting as a simple amplification receiver, the valve can be set into a state of oscillation and employed for the reception of signals by the "beat" method. The adjustments for beats are made roughly with the inductance, but the final adjust-

Short wave set				Long wave set						
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
Length	7.3"	7.6"	7.6"	40"	12"	12"	40"	6"	6"	40"
Diameter	4"	3.5"	3.5"	6"	6"	5"	6"	5"	4"	6"
Size of s.c.c. wire	26	32	32	24	24	30	30	24	30	30
Number of turns	350	550	550	1538	481	754	2513	231	377	2513

Figure 3—1st prize article

ment is obtained through condensers C-1 and C-2 respectively.

The dimensions given for the coils will permit the reception of waves up to approximately 13,000 meters with a single wire inverted aerial L 60 feet in height and 300 feet in length.

For the short wave receiver (200 to 3,000 meters) a smaller aerial is necessary.

The inductance L-8 and L-9 comprise an oscillation transformer which aids in tuning, and through which the regenerative effects are obtained.

By simply throwing switches, S-1 and S-2, in the proper direction either long or short damped or undamped waves may be received.

No provision has been made in this apparatus for opening the filament battery circuit except by turning the rheostat pointer to zero. It may prove advisable to add a two-point switch to the cabinet for this purpose.

A complete set of dimensions with the various coils included in this apparatus appears in the following table:

Ross Moorhead, *Ohio.*

SECOND PRIZE, FIVE DOLLARS

A Short Cut for Experimenters

The six tables in this article I have prepared according to the usual rules for changing C.G.S. or electro-magnetic and electro-static units of capacity, inductance, resistance, current, potential and electrical power to practical units.

Although many wireless experimenters are not in the habit of making mathematical calculations except at long intervals, they have occasion now

CURRENT—TO CHANGE UNITS

Magnetic to practical multiply by 10	Static to magnetic divide by 3×10^{10}
Magnetic to static multiply by 3×10^{10}	Static to practical divide by 3×10^{9}
Practical to static multiply by 3×10^{9}	Practical to magnetic divide by 10

Practical Units Amperes			Electromagnetic Units	Electrostatic Units
1 000 000		10^{6}	10^{5}	3×10^{15}
100 000		10^{5}	10^{4}	3×10^{14}
10 000		10^{4}	10^{3}	3×10^{13}
1 000	(1 Kiloamp.)	10^{3}	10^{2}	3×10^{12}
100		10^{2}	10	3×10^{11}
10		10	1	3×10^{10}
1	(1 Ampere)	1	10^{-1}	3×10^{9}
.1		10^{-1}	10^{-2}	3×10^{8}
.01		10^{-2}	10^{-3}	3×10^{7}
.001	(1 Milliamp.)	10^{-3}	10^{-4}	3×10^{6}
.000 1		10^{-4}	10^{-5}	3×10^{5}
.000 01		10^{-5}	10^{-6}	3×10^{4}
.000 001	(1 Microamp.)	10^{-6}	10^{-7}	3×10^{3}
		10^{-7}	10^{-8}	3×10^{2}
		10^{-8}	10^{-9}	3×10
		10^{-9}	10^{-10}	3×1

and then to change from one system of units to another. This is especially true in connection with calculations of inductance and capacity.

These tables will not only serve to check arithmetical calculations but will permit the desired changes from one system of units to the other without the usual mental effort. The tables also are of considerable assistance in the use of exponential notations as many decimal equivalents therefor are given.

Summed up in their entirety, we have in these tables, a perspective view of the relation between the practical, the electro-magnetic, and the electro-static systems of units.

E. M. KINGLEY, *New Jersey.*

RESISTANCE—TO CHANGE UNITS

Static to practical multiply by $9x10^{11}$ | Magnetic to practical divide by 10^9

Practical Units			Electromagnetic Units	Electrostatic Units
		10^{11}	10^{20}	1/9x 1
		10^{10}	10^{19}	$1/9x10^{-1}$
		10^{9}	10^{18}	$1/9x10^{-2}$
		10^{8}	10^{17}	$1/9x10^{-3}$
		10^{7}	10^{16}	$1/9x10^{-4}$
1 000 000	(1 Megohm)	10^{6}	10^{15}	$1/9x10^{-5}$
100 000		10^{5}	10^{14}	$1/9x10^{-6}$
10 000		10^{4}	10^{13}	$1/9x10^{-7}$
1 000		10^{3}	10^{12}	$1/9x10^{-8}$
100		10^{2}	10^{11}	$1/9x10^{-9}$
10		10	10^{10}	$1/9x10^{-10}$
1	(1 Ohm)	1	10^{9}	$1/9x10^{-11}$
.1		10^{-1}	10^{8}	$1/9x10^{-12}$
.01		10^{-2}	10^{7}	$1/9x10^{-13}$
.001		10^{-3}	10^{6}	$1/9x10^{-14}$
.000 1		10^{-4}	10^{5}	$1/9x10^{-15}$
.000 01		10^{-5}	10^{4}	$1/9x10^{-16}$
.000 001	(1 Microhm)	10^{-6}	10^{3}	$1/9x10^{-17}$
		10^{-7}	10^{2}	$1/9x10^{-18}$
		10^{-8}	10	$1/9x10^{-19}$
		10^{-9}	1	$1/9x10^{-20}$

INDUCTANCE—TO CHANGE UNITS

Static to practical multiply by $9x10^{11}$ | Magnetic to practical divide by 10^9
Magnetic to static divide by $9x10^{20}$

Practical Units Henrys			Electromagnetic Centimeters	Electrostatic Units
		10^{11}	10^{20}	1/9x 1
		10^{10}	10^{19}	$1/9x10^{-1}$
		10^{9}	10^{18}	$1/9x10^{-2}$
		10^{8}	10^{17}	$1/9x10^{-3}$
		10^{7}	10^{16}	$1/9x10^{-4}$
		10^{6}	10^{15}	$1/9x10^{-5}$
100 000		10^{5}	10^{14}	$1/9x10^{-6}$
10 000		10^{4}	10^{13}	$1/9x10^{-7}$
1 000		10^{3}	10^{12}	$1/9x10^{-8}$
100		10^{2}	10^{11}	$1/9x10^{-9}$
10		10	10^{10}	$1/9x10^{-10}$
1	(1 Henry)	1	10^{9}	$1/9x10^{-11}$
.1		10^{-1}	10^{8}	$1/9x10^{-12}$
.01		10^{-2}	10^{7}	$1/9x10^{-13}$
.001	(1 Millhenry)	10^{-3}	10^{6}	$1/9x10^{-14}$
.000 1		10^{-4}	10^{5}	$1/9x10^{-15}$
.000 01		10^{-5}	10^{4}	$1/9x10^{-16}$
.000 001	(1 Microhenry)	10^{-6}	10^{3}	$1/9x10^{-17}$
		10^{-7}	10^{2}	$1/9x10^{-18}$
		10^{-8}	10	$1/9x10^{-19}$
		10^{-9}	1	$1/9x10^{-20}$

ELECTRIC POWER—TO CHANGE UNITS

Practical to static multiply by 10^{7} | Magnetic to static multiply by 1
Practical to magnetic multiply by 10^{7} | Static to practical divide by 10^{7}
Magnetic to practical divide by 10^{7}

Practical Units Watts			Electromagnetic and Electrostatic Units	
100 000 000		10^{8}	10^{15}	
10 000 000		10^{7}	10^{14}	
1 000 000		10^{6}	10^{13}	
100 000		10^{5}	10^{12}	Dyne centimeters
10 000		10^{4}	10^{11}	per second
1 000	(1 Kilowatt)	10^{3}	10^{10}	or
100		10^{2}	10^{9}	Ergs per second
10		10	10^{8}	
1	(1 Watt)	1	10^{7}	
.1		10^{-1}	10^{6}	
.01		10^{-2}	10^{5}	
.001	(1 Milliwatt)	10^{-3}	10^{4}	
.000 1		10^{-4}	10^{3}	
.000 01		10^{-5}	10^{2}	
.000 001	(1 Microwatt)	10^{-6}	10	
		10^{-7}	1	

POTENTIAL—TO CHANGE UNITS

Static to magnetic multiply by 3×10^{10} | Magnetic to static divide by 3×10^{10}
Static to practical multiply by 3×10^{2} | Magnetic to practical divide by 10^{8}
Practical to magnetic multiply by 10^{8} | Practical to static divide by 3×10^{2}

Practical Units Volts			Electromagnetic Units	Electrostatic Units
1 000 000	(1 Megavolt)	10^{6}	10^{14}	$1/3\times10^{4}$
100 000		10^{5}	10^{13}	$1/3\times10^{3}$
10 000		10^{4}	10^{12}	$1/3\times10^{2}$
1 000	(1 Kilovolt)	10^{3}	10^{11}	$1/3\times10$
100		10^{2}	10^{10}	$1/3\times 1$
10		10	10^{9}	$1/3\times10^{-1}$
1	(1 Volt)	1	10^{8}	$1/3\times10^{-2}$
.1		10^{-1}	10^{7}	$1/3\times10^{-3}$
.01		10^{-2}	10^{6}	$1/3\times10^{-4}$
.001	(1 Millivolt)	10^{-3}	10^{5}	$1/3\times10^{-5}$
.000 1		10^{-4}	10^{4}	$1/3\times10^{-6}$
.000 01		10^{-5}	10^{3}	$1/3\times10^{-7}$
.000 001	(1 Microvolt)	10^{-6}	10^{2}	$1/3\times10^{-8}$
		10^{-7}	10	$1/3\times10^{-9}$
		10^{-8}	1	$1/3\times10^{-10}$

CAPACITY—TO CHANGE UNITS

Magnetic to practical multiply by 10^{15} | Static to practical divide by 9x10[illegible]

Practical Units Farads	Practical Units Microfarads		Electrostatic Centimeters	Electromagnetic Units
10^{9}	10^{15}		9×10^{20}	1
10^{8}	10^{14}		9×10^{19}	10^{-1}
10^{7}	10^{13}		9×10^{18}	10^{-2}
10^{6}	10^{12}		9×10^{17}	10^{-3}
10^{5}	10^{11}		9×10^{16}	10^{-4}
10^{4}	10^{10}		9×10^{15}	10^{-5}
10^{3}	10^{9}		9×10^{14}	10^{-6}
10^{2}	10^{8}		9×10^{13}	10^{-7}
10	10^{7}		9×10^{12}	10^{-8}
1	10^{6}	1 000 000	9×10^{11}	10^{-9}
10^{-1}	10^{5}	100 000	9×10^{10}	10^{-10}
10^{-2}	10^{4}	10 000	9×10^{9}	10^{-11}
10^{-3}	10^{3}	1 000	9×10^{8}	10^{-12}
10^{-4}	10^{2}	100	9×10^{7}	10^{-13}
10^{-5}	10	10	9×10^{6}	10^{-14}
10^{-6}	1	1	900 000	10^{-15}
10^{-7}	10^{-1}	.1	90 000	10^{-16}
10^{-8}	10^{-2}	.01	9 000	10^{-17}
10^{-9}	10^{-3}	.001	900	10^{-18}
10^{-10}	10^{-4}	.000 1	90	10^{-19}
10^{-11}	10^{-5}	.000 01	9	10^{-20}
10^{-12}	10^{-6}	.000 001	.9	10^{-21}

The Wireless Class for Women

An Outline of Its Progress to Date, Including the Director's Report to the National Council and an Exclusive Interview

"IN wireless, a new profession heretofore exclusively for men, is now open to women. Fifty years ago women had to contend with the same difficulties in entering the medical profession as the women have had in entering the wireless field, and yet to-day, the most conservative of the colleges, such as Harvard and Columbia, urge women to study medicine. It will not be very long when the value of women's services in this new field will be recognized."

The foregoing observation was made in the office of THE WIRELESS AGE by Mrs. Herbert Sumner Owen, Director, Wireless Class for Women, upon the occasion of her retirement from this field of war endeavor.

By way of illustrating how the class for women was brought to its present efficiency, Mrs. Owen told the following, in an exclusive interview:

"On the seventh of March, 1917, the registration for the Wireless Class for Women at Hunter College was opened. For this class Hunter College had contributed the space and Mr. E. J. Nally, vice-president and general manager of the Marconi Company, the necessary equipment. Fifteen applicants registered and the class was opened on March 12th. It was simply an experiment. It was my belief that a demand existed, and Mr. Nally and Hunter College were willing to co-operate, in order to find out whether there was a substantial number

A class in wireless telegraphy for women

of young women who desired to make themselves efficient for wireless operating, taking the same course and submitting to the same test that men undertake.

"At that time the Marconi School thought it impossible to admit women to its classes, and the East Side Branch of the Y. M. C. A., after putting the question before its educational committee, decided also against admitting women to their classes. But the class opened on March 12th, nevertheless, and ever since there has been a steady flow of applicants; more than 150 women have applied for the various courses which have been instituted.

"In May a few of the more advanced and able students were offered membership in the Marconi School; this was our first real recognition. During the summer an intensive course of ten weeks' duration was offered to teachers, not with the idea that they could become radio operators in that short space of time, but to obtain a comprehensive view of the ground that would have to be covered more at leisure and in greater detail.

"Between March 12th and December 1st, I had under my directorship at Hunter College, three evening divisions, one afternoon division and the intermediate class with sessions from 9 to 4, five days a week, for ten weeks. One student of the Intensive Class went up for the Government test and secured a second grade commercial license.

"Hunter College, however, had no further space to give to the steadily increasing number of applicants, and the Y. M. C. A., in October, reconsidered its decision against the admission of women students and offered the services of an instructor and the use of the apparatus, equipment and class room. The class of nineteen women began work there on October 22nd."

Mrs. Owen now relinquishes her connection with the training of women to be wireless operators and the Wireless Class for Women passes out of existence. Hunter College has incorporated this division in their evening courses and becomes financially responsible for it. The Marconi School has thrown open its doors to admit women students, and the East Side Y. M. C. A. has done the same. Added to these is the College of the City of New York, which until recently shut its doors against women. The college has now decided to admit women, and among the various courses opened to them is a class in radiotelegraphy comprising the elementary engineering branches of the art.

With the opening of the year 1918, when Mrs. Owen's retirement became effective, she submitted the following report to her National Council:

On December 19, 1917, I received from Hunter College, through Professor Lewis D. Hill, a formal notification that the College desired to take over and incorporate in their evening courses, the Division of wireless students installed there. The Division consisted of thirty-five students when transferred.

Professor Hill writes me that in addition to assuming charge of the future of the Division he also becomes responsible for the small financial deficit remaining due the instructors on January 1st, 1918. These instructors are: Professor Hill, Ensign Otto Redfern, U. S. N. R. F., Chas. T. Manning, of the Marconi Company, Miss Catherine Archer, Miss Chess and Mrs. Tuzo.

On January 2nd I wrote Mr. Nally, vice-president and general manager of the Marconi Company, as follows:

Dear Mr. Nally:—

Hunter College has decided that the evening division of the Wireless

Class for Women is of sufficient importance for them to desire to incorporate it in their evening courses, and proposes to take it over and become financially responsible for it.

In the circumstances my intimate connection with this division of the Wireless Class will be severed, and I shall no longer be at Hunter College. Consequently, I surrender with many thanks to you the apparatus which you so generously loaned me for the use of the Wireless Class. As you know, your kindly co-operation made the class possible; without you it could not have existed. Please accept my personal thanks and those of the class, for whom I speak, for your great kindness.

Should Hunter College need the use of the apparatus, may I ask you to be good enough to allow it to remain in their possession so long as the evening division of the Wireless Class is a success.

With reiterated thanks,

Faithfully yours,

Erna vonR. Owen.

At my request, Mr. Nally most kindly consented to continue to Hunter College the loan of the apparatus which he had loaned me for the Wireless Class, addressing to me the following letter:

Dear Mrs. Owen:—

You have reason to be proud of your achievement and what you have done shows at least one instance where a woman performed a man's work, and in a manner of which any man might well be proud.

My congratulations, and best wishes for your continued progress.

Very sincerely yours,

E. J. Nally.

In this connection I feel I must express again for myself the deep appreciation we have of the importance of Mr. Nally's kindness. Had the class not had the use of this apparatus it could not have come into existence, as Hunter College had only space to offer us. It had no radio equipment, and until the class had proved itself, no appropriation could be secured to buy the equipment.

The following students hold first grade commercial licenses: Elizabeth Rickard, Elsie Merz, Georgina Davids, Aline McDonald, Mrs. J. H. Hawley, Mary Murray, E. M. Rhodes, Eleanor Vredenburgh, Alice Davison, Adele Brown, Harriet Ransom, Vera K. Van derWater, Beatrice Eakins and Slora Hamilton. First grade emergency licenses are held by: Helen Campbell and Elise vonR. Owen. The following hold second grade commercial licenses: Mrs. Eila Haggin, Mrs. R. P. Sheehan, M. B. Davey and Evelyn Reading.

Miss Abbie Putnam Morrison has enlisted in the United States Naval Reserve as a "First Grade Electrician-R.", and is on call at present. She is at the Marconi School in the daytime, and in the evening class at Hunter College is preparing to take her Government test so that she may be ready when she is summoned.

While we have not yet placed any of our licensed radio operators, there is a perceptible change in the attitude of the powers that be.

The Marconi School has received a request for two code instructors for a buzzer class in New York, and Mr. Bucher has recommended two students of the Wireless Class for Women.

Professor Lewis D. Hill has recommended that graduates of the Wireless Class be employed as instructors in the buzzer classes being established by the Signal Corps of the Army. There is a great demand for such instructors, far greater than it is possible to supply at present.

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headquarters, 25 Elm St., New York

A Suggestion for Association Members

FRANK R. MOSS.

THE special type of electron relay which I show in the accompanying drawing, figure 1, has never been tried experimentally, but a man of scientific standing has stated that he saw no reason why it wouldn't work.

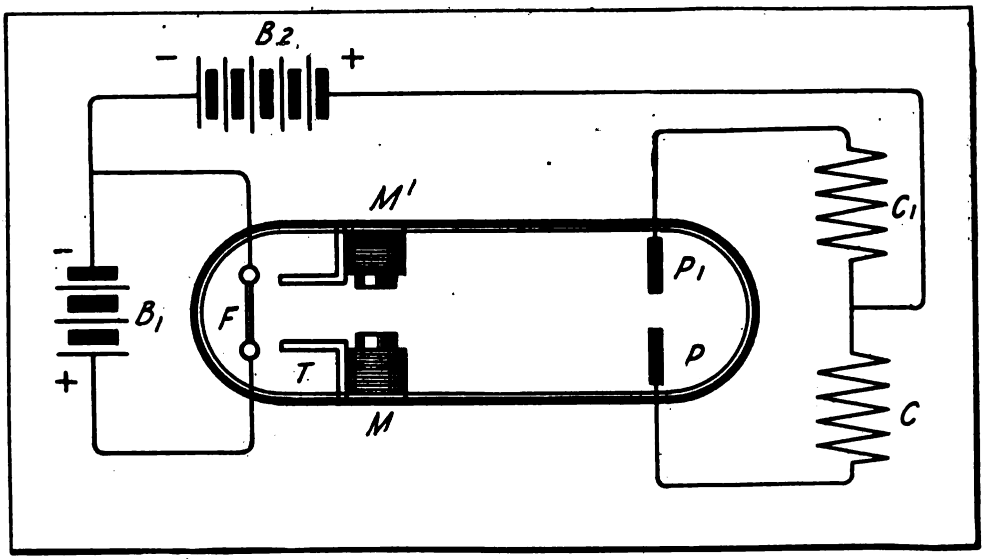

Figure 1

The object of the device is to provide a relay which can be connected in the local circuit of an ordinary receiving set, which in turn will operate a common sensitive telegraph relay (preferably of the polarized type) to work a call bell.

The fundamental principle upon which the working of this apparatus is based follows: If the filament F is brought to incandescence by battery B-1, and furthermore, a second battery, B-2, is con-

(*Continued on page* 348)

The Wireless Man's BOOKSHELF

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The opening chapters review the amateur situation, showing what is expected of the amateur operator, and the requirements of a first-class amateur station. Another chapter is devoted to instruction in the telegraphic code, showing how to wire up a code practice table for the production of artificial radio telegraphic signals for one or more students at a time. Various modifications of buzzer practice systems are described.

The text matter rapidly leads into more advanced experiments, complete data being given, for instance, for the construction of a wavemeter, and instructions for its use under all conditions. This includes tuning, the measurement of inductance capacity of a wireless telegraph aerial, and general methods of calibration. The measurement of the logarithmic decrement is treated in a way easily understood by the beginner. The design and working drawings for several types of low power transmitters are included, covering the construction of a quenched spark gap and apparatus associated therewith.

The receiving apparatus and detectors of wireless telegraphy are treated at length, practically every type of detector in use being described, together with the circuits best suited for the operation of each.

The two-electrode and three-electrode vacuum valves are described and every known circuit for their use is shown. This includes complete cascade amplification circuits, regenerative and beat receivers, heterodyne receivers, etc.

Long distance receiving apparatus for the reception of long waves which will permit the recording of signals over 6,000 miles are shown by diagram and by a complete set of dimensions.

The experimenter is shown how to construct a receiving tuner for any range of wave lengths; how to design a receiving tuner specifically for the reception of Arlington time signals; how to make use of the balancing-out aerial for the elimination of interference; one chapter is devoted to the construction of variometers in various forms.

The amateur is told how to construct a simple wireless telephone by use of a battery of vacuum valve oscillators. Numerous experiments are described, showing how to get the best out of a given transmitter and receiver.

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Specialists in Wireless Literature

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(*Continued from page 342*)
nected to the two plates P and P^1, a steady flow of electrons from F, to P and P^1 will take place. And due to the fact that both P and P^1 are charged to the same potential, the flow of electrons from the filament will divide equally, and as a result an equal amount of current will flow through coils C^1 and C.

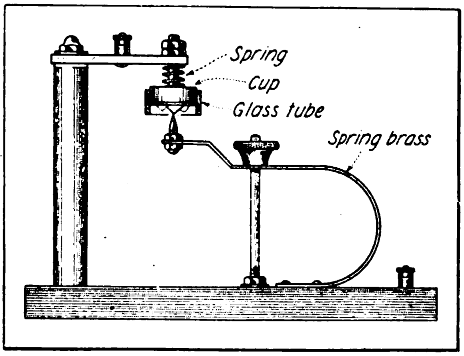
In the space between the filament F and the plates P, P^1, are placed two magnet coils M and M^1, consisting of a considerable number of ampere turns. These are connected in series and in turn with the local detector circuit of a standard receiving system.

If these magnets are connected in the circuits of a receiving system in which, for instance, the effect of the incoming oscillations is to increase the local battery current, then previous to the receipt of signals, there will be a slight deflection of the electrons from their normal path; for the purposes of illustration we may assume this to be in the direction of plate P. Then when incoming oscillations flow through the detector circuits, electrons will be deflected to a greater degree so that practically all of them will impinge upon plate P. Owing to the slightly increased potential of plate P, a still greater flow of electrons will be drawn from the filament F, so much so that the circuit from F to P^1 is practically broken. Then, as a result, if the telegraph relay is inductively coupled to the coil C^1, it will receive a pulse of current which will draw over its armature. This in turn may close the circuit of a call bell.

It would, of course, be possible to connect the telegraph relay in series with either plate P or P^1, but now that the fundamental principle is understood, various deviations from this circuit may be employed.

It is, of course, essential, in the operation of this device, that the circuits PC and PC^1 have identical values of resistance, and that the plates P and P^1 be symmetrically placed in respect to the filament F. It will also be observed that this apparatus can work in one of two ways: the increase of current through circuit P, for instance, may be made to close a telegraph relay, or the decrease of current through circuit P^1 to open the circuit of a telegraph relay.

Members of the N. A. W. A. who have facilities for construction of a device of this kind would greatly oblige the writer if they would inform him through the columns of The Wireless Age of the results obtained.



A dust-proof detector

A Dust-Proof Detector of Simple Design

The accompanying diagram shows how the amateur may, with parts that he can find about his workshop, construct a dust-proof detector which will permit extremely close adjustment. It will be observed that a crystal is mounted upside-down and that a short pointed tack mounted on a flexible piece of spring brass makes contact with the crystal. By more careful adjustment of the knob attached to the upright post, the tension of the contact point is increased or decreased.

As a further protection to the crystal, it is surrounded with a small glass tube which is about ½ inch in length.

—E. T. J.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

A. L. R., New Orleans, La., writes:

Ques.—(1) I am an operator in the commercial wireless service and I would like advice on the functioning of the former valve tuner developed by the American Marconi Company. I refer to those tuners which now employ crystals but formerly the valve. What is the function of the small six-point switch on the top of the tuner marked "Long Wave and Tune"?

Ans.—(1) The function of this switch is to shift the variable condenser ordinarily connected in shunt to the intermediate circuit and to place it in shunt to the closed oscillation circuit. This permits adjustments to waves of a greater length than those afforded by the billi-condenser alone. This change is made in order that the original valve tuner will respond to the time signals from Arlington, which are sent out at the wave-length of 2,500 meters.

Ques.—(2) Where can I obtain a detailed wiring diagram of the valve tuner?

Ans.—(2) This tuner, in commercial service, is known as type 107a. The circuits are completely explained in "Practical Wireless Telegraphy," copies of which can be purchased from the Wireless Press, Inc., 25 Elm Street, New York City.

Ques.—(3) Will you please advise how the tone of the quenched spark discharger can be regulated to a musical pitch?

Ans.—(3) Provided the gaps of the quenched discharger are airtight, the adjustment for a clear pitch is generally obtained by variation of the generator voltage. It is of course essential that the speed of the alternator be adjusted so that when the transmitting key is closed the frequency is 500 cycles per second.

If the note of the quenched gap has been adjusted for clearness and the open and closed oscillation circuits of the transmitter are thrown out of resonance, the pitch of the note will be destroyed because there will be, under this condition, a smaller extraction of energy from the spark gap circuit and the potential difference across the gap will accordingly rise. A pure tone can never be obtained with a leaking gap, and consequently, possible leakage between the gaskets should be carefully watched for.

* * *

L. A. W., Seattle, Wash.:

We have carefully studied your diagram of connections for the double vacuum valve amplifier and associated circuits, and we agree that you have developed what may be considered a universal receiving set.

We presume that the iron core transformer (shunted by the condenser C-1) in the grid circuit of the first valve is intended for purposes of re-enforcing the audiofrequency current of the plate circuit back upon the grid, and if so, the diagram is correct.

We consider an apparatus such as you have constructed to be practical for the advanced experimenter, but we would not recommend the construction of such a complicated set upon the part of the beginner. As a simple circuit for the beginner, we recommend the use of but one bulb with a regenerative coil for amplifying simultaneously the audio and radio frequencies.

The sensitiveness of your set can be generally increased by placing a radio-frequency transformer between the first and second bulbs. Thus you would amplify radio-frequency currents and increased selectivity would result.

* * *

H. G. H., Craften Heights, Pa.:

You neglected to tell us the type of motor you employ to drive your rotary disc discharger, and consequently we cannot advise you how its speed can be reduced. Have you tried a series rheostat?

* * *

R. J. E., Southampton, N. Y.:

Balancing-out circuits such as are described in "How to Conduct a Radio Club" have been employed for tuning out induction from power wires, but in many cases the results have not fully justified the construction of the extra apparatus required.

We can offer the readers of The Wireless Age no advice on the vacuum valve situation as far as the amateur is concerned until the close of the war.

* * *

J. E. L., Michigan, N. D.:

The commutator interrupter which you have designed will function well enough with a one or two-inch spark coil, but not on larger powers. Severe arcing at the commutator segments would result. In general, interrupters constructed along the lines that you have suggested give no better results than the ordinary magnetic in-

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terrupter except that they are slightly more positive in action, i. e., fusing is prevented.

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* * *

G. A. G., Baltimore, Md., inquires:

Ques.—(1) Please explain what is meant by radio-frequency amplification in connection with the three-electrode valve.

Ans.—(1) When the vacuum valve is connected to the secondary circuits of a receiving tuner there is repeated in the local plate circuit a radio-frequency current which is in reality the result of an increase and decrease of the voltage of the plate circuit battery. There are two methods by which this radio-frequency component of the battery circuit can be amplified. In one system the plate circuit is coupled back, either electromagnetically or electrostatically, to the grid circuit, and by the variation of the grid potential thus occasioned, considerable amplification is obtained

In the second method, the radio-frequency component of the local plate circuit is passed through the primary winding of an oscillation transformer and the terminals of the secondary winding are in turn connected to the grid and filament of a second valve in which the incoming oscillations are again amplified.

Ques.—(2) How can an operator tell when a radio-frequency amplifier is adjusted to its best operating condition?

Ans.—(2) If the operating characteristic of the bulb in use has not been obtained by laboratory experiment, the adjustment must be found by practical test. Usually, in the radio-frequency amplifying system a battery is connected in series with the grid of the valve. This battery is shunted by a potentiometer, and by means of it the potential of the grid in respect to the filament can be definitely adjusted. This permits the best operating characteristic to be obtained which is evidenced in the operator's telephone by the best strength of signals.

* * *

B. D. L., Washington, D. C., inquires:

Ques.—(1) In what part of a receiving tuner circuit should a variometer be placed?

Ans.—(1) The position of the variometer depends somewhat upon the type of circuit in use. In general, it should be placed in series with the aerial circuit, although it may be useful in certain types of apparatus in series with the secondary inductance. The advantage of the variometer is that it permits extremely close regulation of the self-induction of a given circuit.

It is particularly useful in the antenna circuit of a regenerative beat receiver. After all circuits of such a receiver are adjusted to resonance, the note of the signals in the head telephone can be varied over a considerable range of frequency by simply turning the handle of the variometer.

Ques.—(2) Will you kindly show a diagram indicating what is meant by a tuned plate circuit and one which is untuned?

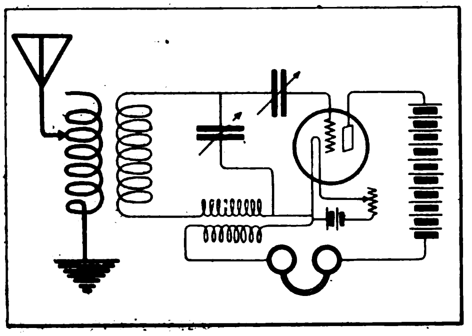

Figure 1

Ans.—(2) The diagram of Fig. 1 shows an untuned plate circuit which is inductively coupled to the grid circuit of a valve. This circuit will permit regenerative amplifica-

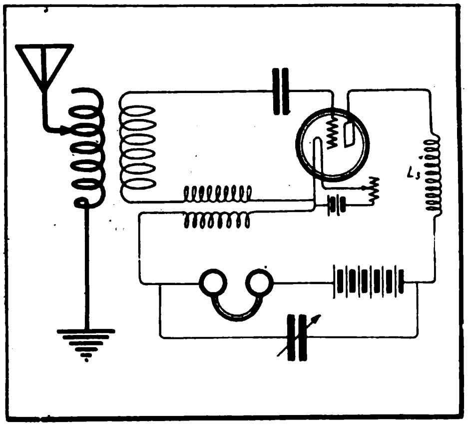

Figure 2

tion. In Fig. 2 is shown a tuned plate circuit where, by shunting a condenser across the battery and placing a coil L-3 in series resonance with the grid circuit oscillation is secured.

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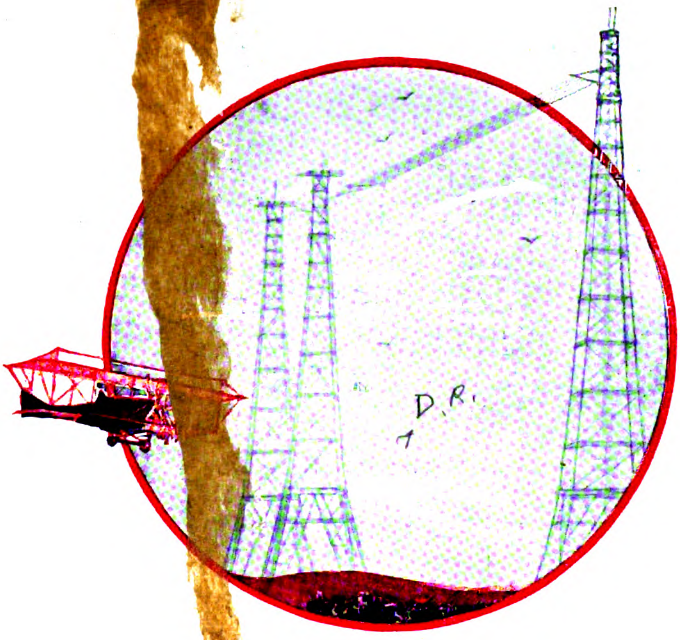

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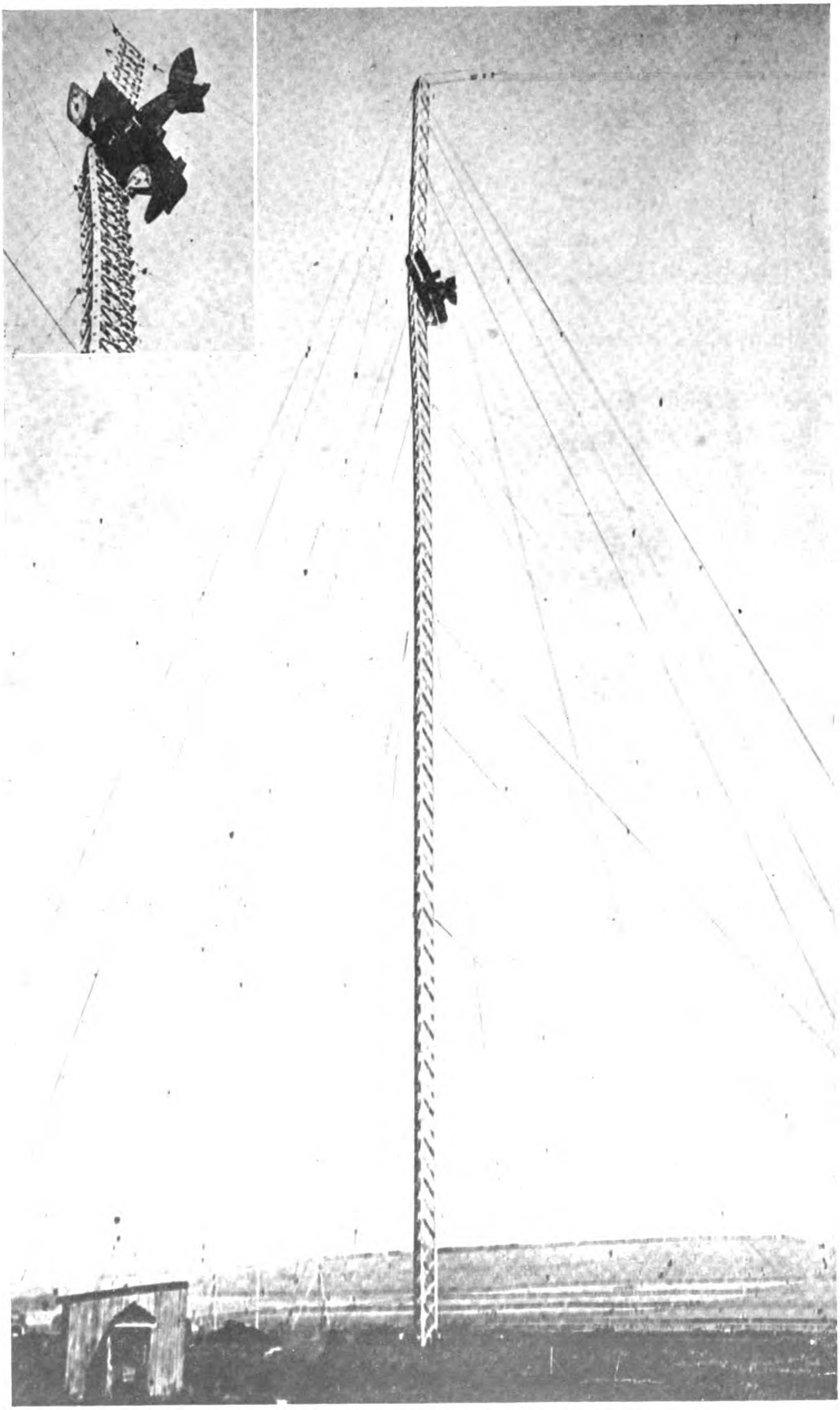


Airship Caught in the Girders Atop a Wireless Tower

THE WIRELESS AGE

WORLD WIDE WIRELESS

The Significance of the Cavite Opening

ON December 19th wireless communication was established between Washington, D. C., and Cavite, P. I., through two relay stations. These relay points are San Diego, Cal., and Pearl Harbor, in the Hawaiian islands. From Pearl Harbor to Cavite, a distance of 4,700 miles, communication will be direct. Thus will the most remote of our possessions be brought into almost instantaneous touch with the seat of government.

Recalling the days of '98, when the battle of Manila bay was fought, the Philippine cable was cut, and the nation waited in breathless suspense until the cable finally was repaired and Dewey laconically reported the victory, great progress in electrical research work has been made within two decades. We get news these days while it is still fresh, and it scarcely matters in which quarter of the world it is made. Never again, it would seem, will a duplication of the Oregon's dash around the Horn keep us in a state of nervous uncertainty for weeks. Wireless, a novelty ten years ago, has become as indispensable as it is reliable. As a means of communication it is a cable that cannot be cut and a wire that storms do not break.

Our wireless equipment is probably equal, if not superior, to that possessed by Germany. When the next step is taken, and the nation's head is enabled to communicate direct with the uttermost outpost where flies the American flag, much after the fashion of a corporation manager who presses a button and instantly is put in touch with a department subordinate, it should have the moral effect, at least, of bringing the widely separated fragments of the republic into closer unification. In any event, the present achievement stands as a Yankee challenge to German kultur.

The Women Break Down the Barriers

AFTER many years of effort women at last have succeeded in breaking down the sex barrier at the College of the City of New York. Announcement was made January 14th that the board of trustees had decided that women might enter the evening and summer classes as fully matriculated pupils, beginning with the classes of February 13th, for which registration opens January 28.

"Our admission of women in the evening session on the same basis as men," says the official announcement, "opens a big vista in education in New York for which women have long been eager. The division of vocational subjects and civic administration has attained a phenomenal growth, and female students will now obtain its advantages and other adjuncts of the entire evening session."

This development was brought about by the efforts of 100 Brooklyn women who tried to register for the last session. It is stated that there are now 500 women who have been taking the courses without prospect of degrees who will be able to compete for the A. B. degree, without payment of fees, on the same terms as men. The trustees authorized President

Sidney E. Mezes of the City College to enter negotiations with President Davis of Hunter College for the purpose of making arrangements for interchangeable work.

The plan contemplates a zone system under which each college will control the students of its particular zone, and the women of Hunter can take advantage of the City College courses where there are no similar classes in their own zone. The idea of the new plan is tó have the two institutions work together.

The credits for studies pursued under the City College jurisdiction will be certified by that college and the A. B. degree will be awarded by Hunter.

Among the changes in the faculty of the College of the City of New York, taking effect February 1, Dr. Alfred N. Goldsmith, radio engineer and director of the City College wireless station, has been made an assistant professor of electrical engineering.

Station Near Where German Is Interned

A MORE strategic location could not have been chosen for an eaves-dropping wireless receiving station than was selected by William Heuer, 19 years old, when he set up in the barn of his father, Henry Heuer, on the main street of Bay Shore, L. I., the wireless apparatus that was raided on December 18th by the Naval Intelligence Bureau.

With the internment on the same day of Henry Schneider, a German jeweler, it was recalled that this Long Island village, near New York has been the scene of other alien enemy activities.

In the summer of 1915, Mme. Gadski, the opera singer, wife of Hans Tauscher, who was representative in this country of the Krupps, rented a cottage in Bay Shore. In August of that year she "entertained" Wolf von Igel, in whose offices in Manhattan the Secret Service agents found a mass of valuable evidence which is thought to have shown what part Ambassador von Bernstorff was playing in the propaganda. There were other notable Germans in the party. Leaving the meeting the party was proceeding westward a short distance from Babylon, when one of their automobiles was wrecked by collision with another car and von Igel was injured. He was taken to the Babylon Hospital where a veil of mystery was thrown about him. He remained there a week without his identity becoming known. Captain Boy-Ed, military attache of the German Embassy, was one of the distinguished visitors who were shown into von Igel's private room to "offer their sympathy."

Von Papen's eagerness to prevent it from becoming known that von Igel had been in Bay Shore on that night was not appreciated at that time. It is not known even now, in view of what was discovered through the recent arrest, whether the wireless espionage scheme was devised at that time, to be put in operation in the event of this country's entry into the war against Germany.

Heuer's station was located nine miles from the wireless station at Sayville, which is owned by German capital, but which is now under the control of the Navy Department, and about the same distance from the wireless station on Fire Island.

No one in Bay Shore suspected that young Heuer and Henry Schneider, the German jeweler, who is now interned, were operating this secret means of intercepting news of troop movements, as is charged. Schneider kept a small jewelry shop on Main street, not far from Heuer's grocery store and barn. Apparently he was paying strict attention to the warning to all Germans to "Mind your own business and keep your mouth shut." His tactics outwardly were directly opposite to those of another Main street merchant of pro-German leanings. He and his wife joined the Red Cross in the recent drive for membership as a sign in his store window indicates.

The man who "tipped off" the Naval Intelligence Bureau to Schneider's actions had seen the jeweler leave his store late at night after all the stores of the village were closed. Schneider always went west. He was followed by the man who watched but who hesitated to take any steps that might arouse the German's suspicions and hinder the subsequent investigation. He was the only man who thought Schneider other than a plodding storekeeper.

Henry Heuer, the father of William, said that he washed his hands of the whole affair. The wireless apparatus, he contended, had not been operating since the war began, though it had been previously.

Hidden German Apparatus Unearthed by Dog

IF YOU place the tip of your finger on a map of the world and run it along the equator, writes "An Australian Officer" in the Wide World, you will discover the island of Nauru. This pin-point of an island is perhaps the richest spot on earth, being composed almost entirely of phosphate, of which it is said there is $950,000,000 worth actually in sight.

Prior to the war the Germans had erected a high-power wireless station on this island, the lofty mast of which is visible a couple of hours before one sights the land from a steamer.

Very soon after the struggle commenced the British authorities "rushed" the place in order to silence the great station. On the near approach of the warships the Huns in charge tried to render the station useless by hiding all the essential parts in a big cave, the existence of which was a secret.

When the station had been thoroughly dismantled and all parts stowed away in their subterranean hiding place the mouth of the cave was closed and hidden with rubbish.

Alas for the Germans! An old black dog had been an interested onlooker.

When the British looked for the wireless the dog joined the side of the victorious party and led the English sailors to the concealed mouth of the cave, where she commenced to dig.

There were sharp-witted fellows looking on, and the excited animal was soon assisted by a band of helpers who were missing nothing. They soon made the earth and rocks fly, uncovered the cave—big enough to hold a platoon—and, to their huge delight, located the missing parts. As a result in a few hours the British were in communication with their warships.

Naval Operator Under Fire in California

A MYSTERIOUS attempt to kill the operator at the United States naval radio station at Inglewood, Cal., with the probable subsequent destruction of the station's valuable electrical equipment, was made on the afternoon of December 8th, according to a report made to the Sheriff's office. The plot failed, the authorities believe, through the presence of mind and quick action of Oliver Garver, the intended victim, who switched out the lights and called the Sheriff's office, frightening away the plotters before they could carry out the first step of their plans.

Garver, an enlisted man detailed as operator at the station, was sitting with his back turned to the windows of the receiving-room on the ground floor when, without warning six shots were fired in quick succession. As the bullets whizzed close to his head and found their mark in the wall ahead of him, Garver quickly turned out the electric lights with one hand and grasped the telephone with the other.

Before the last bullet buried itself in the wall, he dropped to the floor and, lying prone in the darkened room, began to call the Los Angeles central. Foiled by the operator's quick action, and not daring to remain in the vicinity of the building, the men outside took a few parting shots in the direction of the second floor of the building, where the transmitting apparatus of the station is installed, and fled from the premises, the officers state.

Some of the bullet holes through the wall showed, by the angle at which they were made, that a number of shots, presumably fired after the lights were extinguished on the ground floor, were aimed in the direction of the floor above. This leads the officers to believe that the plotters were familiar with the general plan of the building and knew where the bullets were apt to find a vital mark.

Pan-American Wireless Project

THE wonders of wireless telegraphy have been made the subject of many a poetical dissertation, but the theme is one of which we never tire, because something new is always being planned or achieved.

It was a marvel when the first telegraphic communication without the aid of wires was established, but the skeptical sneered at the suggestion that any practical use could be made of the device, and, of course, were absolutely certain it could never have the range of line telegraphy.

From little more than a pretentious scientific toy, wireless was soon installed on ships, and it was thought it would be of inestimable benefit to mankind if it could only serve the purpose of calling for aid when a vessel struck upon the rocks or was foundering anywhere near a coast.

Bit by bit the plants were improved until first the seas and then the oceans were spanned. Messages to ships in midocean could be relayed to stations on the opposite side, and that seemed wonderful until it was found possible to communicate from one hemisphere to another without the aid of vessels at sea. From this it was only a step to sending wireless messages all round the globe; men at a station in the mid-Pacific talking to New York, London, Berlin, Tokio, Melbourne and Alaska.

With this accomplished science could no further go, and all that remained was for commercial enterprise so to extend its operations as to cover the whole globe with radio stations working on a business basis. Science had proved that the thing could be done, and it was for commerce to make wider and wider uses of the invention.

Of the many recent commercial extensions of wireless, perhaps the most important project is that of the Pan-American Wireless Telegraph and Telephone Co., which seeks to establish communication between the United States, Mexico, Central and South America.

With such a concern in successful operation, Pan-Americanism will be advanced as it could have been by no other means. The various republics will be brought into the most intimate touch with one another, and if better knowledge is the basis of better understanding and better understanding of better friendship the Americas may become more united than ever through the unifying influence of wireless communication.

There could be no more favorable time than the present for such an undertaking. Cut off as is the Western world from communication through trade with Europe, it has immediate need of taking every advantage of its commercial self-sufficiency. This hemisphere is a world unto itself, and, if necessary, can live unto itself so far as trade and commerce are concerned. The war having presented that necessity, nothing can assist in the work of demonstrating how self-contained we are like more immediate communication of our wants and resources.

It may well be, if this is to prove a very long war, that the Americas will foster mutual trade on a basis undreamed of in the days of peace, and to this much desired result a Pan-American wireless system can contribute largely.

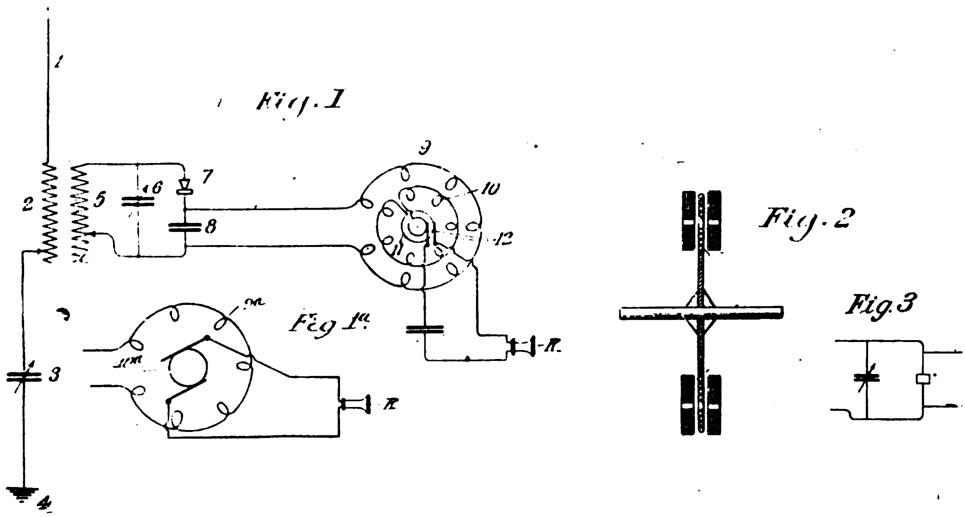
More closely welded together by commerce, we will be more of one mind on those world problems of mutual concern, and, as the essentially peaceful hemisphere, we may be promoting the universal concord of mankind.

A world united by wireless may prove more united than it could be by any other means.

Radio Science

Receiving Apparatus for the Production of Sinusoidal Alternating Currents

IT is a well-known fact that if a sinusoidal alternating current flows through the ordinary telephone receiver such as is used in a wireless telegraph system, better response is obtained from a given amount of energy if the diaphragm is acted upon at a certain natural frequency, that is, the greatest volume of sound is produced by the telephone diaphragm when its natural frequency coincides with the frequency of the current. While the foregoing statement applies to a receiving telephone passing a sinusoidal current, such is not the effect of a group of incoming oscillations when they are rectified in a radio receiving system. The telephone winding is traversed by a series of decaying pulses of direct current which obviously cannot produce the same effect on the diaphragm as a sinusoidal alternating current.



Diagrams of a recently devised radio receiving system

It has been shown by Dr. Austin of the Bureau of Standards that it requires but .0000006 of a volt to produce an audible sound in a standard type of receiving telephone when the frequency of the current is 900 cycles per second; at 60 cycles per second six hundred and twenty millionths of a volt are required to produce the same strength of signal. From this we may deduce that a given amount of energy flowing through the head telephone produces the greatest deflection of the telephone diaphragm, when the telephone windings are traversed by a current of a definite and sinusoidal frequency.

Harry Shoemaker recently devised a radio telegraph receiving system wherein the rectified currents flowing through the local receiver circuits pass through the field windings of a small alternating current generator, the armature of which contains a series condenser 13 and a telephone, *R*, as shown in figure 1.

The effect of condenser, 8, connected in shunt to the field windings, is to provide a practically continuous flow of current through the field windings of 9, a small alternating current generator.

It is evident that the circuits shown (Figure 1) are applicable to the reception of either damped or undamped oscillations, but increased response is obtained over the ordinary system on account of the fact that the armature of the alternator impresses upon the telephone, *R*, a practical sinusoidal alternating current and if the frequency of this current coincides with the natural frequency of the telephone's diaphragms, a maximum of sound is obtained.

Increased strength of signal is obtained by reason of another well-known phenomenon. With damped oscillations, for example, the energy which can be transmitted from the sending to the receiving station is proportional to the spark frequency or the number of wave trains per second, and it is advantageous to increase the number of wave trains radiated from a transmitting station provided a receiver is employed which will act quantitatively, or have its action increased by the amount of received energy. To illustrate further: with any of the well-known crystal, electrolytic, or rectifying detectors if used in conjunction with the galvanometer, the reading of the galvanometer will be approximately proportional to the spark frequency when damped oscillations are used, provided the energy or amplitude of the wave train is constant.

For instance, if 1,000 wave trains are received per second, the galvanometer will show approximately one-half the energy received that it would if there were 2,000 wave trains per second. On the other hand, if a telephone is used in place of a galvanometer, it will not give any louder signal with 2,000 wave trains per second than with 1,000 wave trains per second, and the loudness of signals depends upon the amount of energy contained in each wave train.

As mentioned before, the electromotive force to which the telephones are subjected in radio telegraph receivers is in the nature of very short impulses with considerable time intervals between such impulses. Therefore, there cannot be much building up or increase of the strength of signals due to resonance, even if the circuits are properly adjusted, that is, if the frequency of the incoming wave trains coincides with the natural period of the telephone diaphragm. But the foregoing limitations are done away with in Shoemaker's apparatus.

By properly choosing the speed of the armature, 10, a note of any desired frequency can be obtained in the telephone, *R*, during the reception of undamped waves.

Mr. Shoemaker points out that while the receiving apparatus is particularly adapted to receive undamped waves or waves having a group frequency higher than the frequency of the telephone or above audibility, it may also be used to advantage in cases where the wave trains have the desired audio frequency. In this case, the generator is modified as shown in Figure 1a, where the alternating current armature has been replaced by a direct current armature. Then, when current flows through the field windings, 10*a*, the armature circuit will be impulsed periodically by an audio frequency current and response accordingly obtained in the head telephone, *R*. A section of the proposed generator is shown in figure 2, and a modified method of connecting the generator across the rectifier, 7, in figure 3.

The Valve Receiver for Wireless Signals

AN unusual circuit for use of the three-electrode vacuum valve as a current limiting device has been brought forth in London by George M. Wright, for the English Marconi Company.

The tube as he employs it offers a striking contrast to the usual three-electrode valve, because instead of employing a high voltage battery, a very small potential difference—in fact, a fraction of a volt—exists between the plate (anode) and the grid.

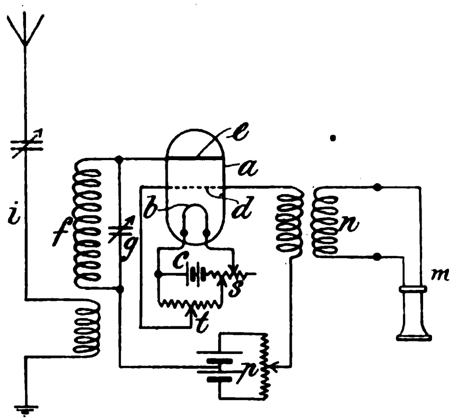


Figure 4—Wright's use of the valve as a current limiting device

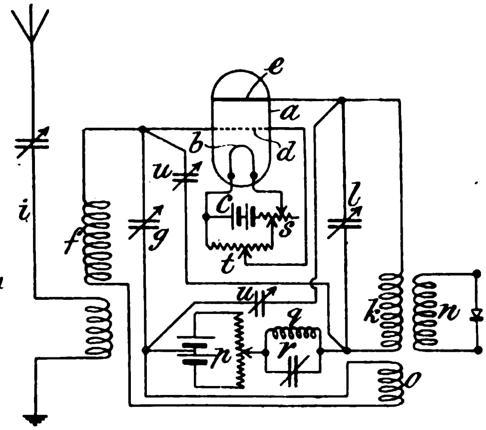


Figure 5—Two tuned oscillatory circuits conductively coupled

The valve employed as a simple detector of oscillations is shown in figure 4, and in figure 5 a modificatioon of the circuit is shown where two tuned oscillatory circuits are conductively coupled.

An inductance *f* coupled to an aerial *i* and shunted by a condenser *g* is connected to the anode *e* and through a potentiometer *p* to the grid *d*. The telephone receiver is coupled at the point *n*. The grid *d* is also connected by a variable contact to a potentiometer *t* and connected across the battery *c*.

For a given position of this variable contact, a certain limiting current can flow across the space between *d* and *e* with a given brilliancy of the lamp filament. The maximum current for any given adjustment may be called the saturation current.

The three main adjustments for placing this apparatus in operation follow:

The temperature of the filament is adjusted by *s*, the potential of the grid by the potentiometer *t*, and the most sensitive point on the rectifying curve is utilized by potentiometer *p*. The maximum strength of the signals is limited by the adjustment of *t*. More clearly, by varying the potential applied to the grid with respect to the filament, the operator can make effective only a small portion of the electronic emission from the filament. If the correct operating adjustment is thus secured, the current will quickly rise to a maximum, this maximum being limited at the same time by the adjustment of the potentiometer *p*. This arrangement gives a very sensitive detector for incoming radio signals, but prevents overpowering noises from static disturbances.

In connection with the circuit of figure 5 Mr. Wright states that the signals in the aerial are transferred inductively to the circuit *f g*, and the space between the grid *d* and the anode *e* acts as a conductive coupling between the two circuits *f g* and *k l*, by completing a circuit through *k*, *g*, potentiometer *p*, *o*, and *f*, the circuit *k*, *l*, being coupled to the detector circuit *n*. The limiting value of the current is controlled, as before, by *t*, and the sensitive point is found by the potentiometer *p*. *Q* is a choke coil and *r* a condenser shunting it. *O* is a reaction coil for balancing accidental electro-magnetic coupling between the circuits. In place of *o*, or in addition, condensers *u* may be inserted as shown, these condensers furnishing a discharge path around *k* for stray oscillations of high frequency. The circuit is arranged to transfer the high frequency current through it to the detector circuit *n* with any required limitation of signals.

The inventor states that during the practical operation of the set the limitation of signals and other responsive sounds in the receiving circuit is obtained by varying the current in the filament *b* so as to control the brilliancy thereof, and the quantity of electrons emitted. Simultaneously the position of the contact at *t* is varied to control the potential between the filament *b* and the grid *g*.

A Receiver for the Elimination of Static Signals and Harmonics

A RECEIVING apparatus applicable to either radio telegraphy or telephony, recently devised by John Carson, has an interesting provision for eliminating static or other unwanted signals. It also prevents distortion of the incoming signal at the receiving apparatus, and therefore permits the receiving telephone in a wireless telephone system to give a response which is directly proportional to the modulated energy supplied by a transmitter.

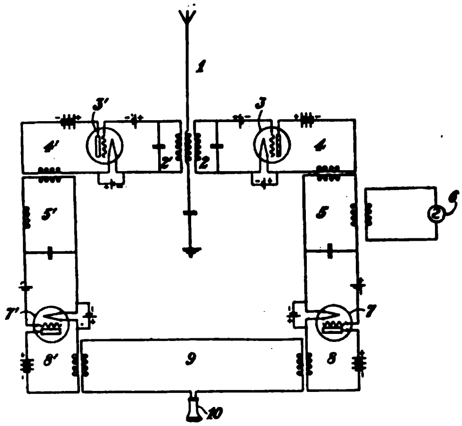


Figure 6—Diagram of circuit for partially eliminating static and foreign interference

A circuit for the partial elimination of such interference is shown in figure 6, and a more elaborate system which acts more effectively in this direction in figure 7. It will be noted that in either system the local output circuits of a number of vacuum valves are differentially connected to a receiving telephone, 10, figure 6. Also, in figure 6, there is coupled to the receiving system, 2, a radio frequency generator 6, coupled to circuit 5. The object of this generator will be explained further on.

In the carrying on of a conversation by wireless telephony, radio frequency current (above the limits of audibility) are employed at the transmitter and are modulated at an audio or "mean speech" frequency by the microphone transmitter. This radio frequency wave is termed the carrier wave, and the modulation of the carrier wave results in general, as is well known, in the transmission of three waves of frequency which may be designated as F, F + f, and F — f; where F is the frequency of the carrier wave and f the frequency of the signal wave (of audio frequency).

In the ordinary receiving system, the oscillations in the receiver are not faithful copies of the original oscillations in the transmitter, and in consequence the signals are distorted; but the Carson apparatus provides means to greatly reduce this distortion.

It is seen from the general circuit shown in figure 6 that the two receiving detector circuits are differentially connected to the same receiving device. Hence, it will be clear that the receiving telephone will not be energized since the oscillations in two similar and equal receiving arrangements oppose and substantially neutralize each other. But in this system, by coupling the generator, 6, to one of the circuits, the oscillations in the two receiving arrangements do not completely neutralize, but the neutralization extends only to oscillations which are conducive to distortion, and which should be eliminated.

In the operation it is desirable that the coupling of generator 6 to circuit 5 should be loose, in order that generator 6 shall not affect to any extent the natural oscillations in circuit 5. Connected to oscillation circuits 5 and 5′ are detectors 7 and 7′, respectively, preferably of the vacuum tube type and similar and equal

as regards adjustments and operating characteristics. Differentially coupled to output circuits 8 and 8′ of detectors 7 and 7′ is coupled a circuit, 9, containing a receiving device, 10, preferably a telephone receiver. Circuit 9 is coupled to circuits 8 and 8′ in such a manner that no sound is heard in the telephone receiver when generator 6 is removed. When this condition obtains, the oscillations of audio frequency in circuits 8 and 8′, excited by the waves absorbed by the antenna 1, oppose and substantially neutralize with respect to circuit 9 and receiver 10. The operation of the system shown, when generator 6 is generating a wave of carrier frequency, will be readily understood from the explanation now to be given, from which it will be seen that not only is the quality of the received speech signals improved, but interference is also largely reduced.

The radiated wave which acts inductively on antenna 1 excites therein oscillations of the carrier frequency F, which is modulated at an audio frequency, f, and such a wave can be analyzed into three component waves of constant amplitude and frequencies, F, F + f, and F — f. These three frequencies are excited in the receiving antenna.

The suppression of two of these frequencies, yet permitting the desired frequency to operate the receiving telephone, is accomplished as follows:

Assume for definiteness that the antenna is tuned to F plus mean speech frequency. As a consequence the current of frequency F—f is reduced in amplitude as compared with the current of frequency F + f, and this reduction may be made as great as desired by sharp tuning and by providing oscillation circuits between the antenna and the detector. It can therefore be assumed that the currents of frequency F — f reaching detectors 7 and 7′ are negligibly small in comparison with the currents of frequencies F and F+f (Figure 6).

It will be readily seen that since the two paths whereby the receiving circuit proper 9 is coupled to antenna 1 are similar and equal, equal currents will be excited in the two circuits by the oscillations induced in the antenna. Therefore, if generator 6 were removed no current would be induced in circuit 9, since its connections with circuits 8 and 8′ are differential. Generator 6, however, generates a wave of constant amplitude and of carrier frequency F; the resultant wave of frequency F is therefore larger in circuit 5 than in circuit 5′, while the waves of frequency F + f are equal in said circuits.

It has been experimentally shown that the action of the valve detector is such that two waves of frequencies F and F + f presented to the input circuit excite in the output circuit audio frequency oscillations of frequencies f and 2f respectively, the latter wave being independent of the wave of frequency F, while the wave of frequency f is proportional in amplitude to the product of the amplitudes of the input waves of frequencies F and F + f. It is the wave of frequency f which reproduces speech signals, the wave of frequency 2f representing an interfering or distorting harmonic. The waves of frequency 2f being independent of frequency F are generated with equal amplitude in circuits 8 and 8′, and hence neutralize in the receiving system while the desired wave of frequency f, since its amplitude depends upon the amplitude of frequency F, is generated with greater amplitude in circuit 8 because frequency F is reinforced in that circuit by generator 6, and hence frequency f is not neutralized. In other words, the receiving system of this invention transmits to the receiver proper the wave necessary to set up sound vibrations therein which are faithful copies of the transmitted signals, while suppressing oscillations which serve only to distort the received signals.

Furthermore, the signals may be amplified by making the wave of generator 6 large as compared with the received wave. As regards static interference, the amplitude of static is in general much greater than that of the wave it is desired to receive and the interference is represented largely by an audio-wave proportional to the square of the static or interfering wave. This term is completely neutralized by the differential connections of this receiving system, which provides a large measure of protection from static or other foreign interference.

In the circuit shown in figure 7, which is designed to eliminate static or

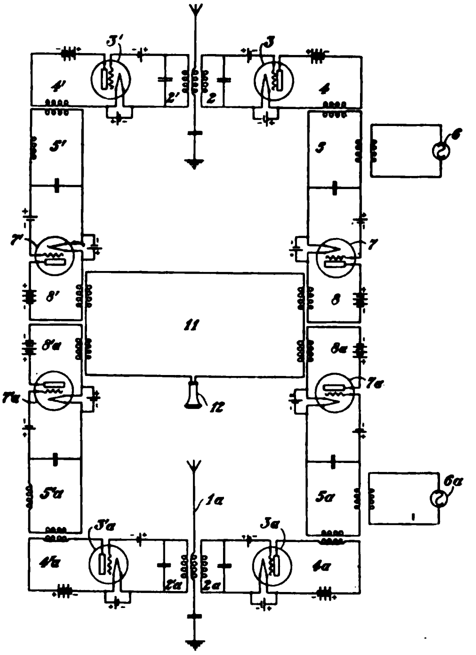


Figure 7—An effective system for the elimination of static and natural disturbances

other natural disturbances, the function of the receiving antenna, 1a, is to eliminate interference, its associated circuits being tuned to a frequency differing materially from the frequency adjustment of antenna, 1, which is tuned to the desired signal.

When a static disturbance sets up oscillations in the antenna, 1, it simultaneously excites oscillations in antenna 1a, the periodicity of the natural oscillations in antenna 1 differing by approximately 1,000 cycles per second, or mean speech frequency, from that of the wave generated by generator 6, while the periodicity of the natural oscillations of antenna 1a is that to which said antenna is tuned. Generator 6a is adjusted to generate a wave whose frequency differs from that of the natural oscillations of antenna 1a by substantially the same amount as does the wave generated by generator 6 from the natural frequency of antenna 1. Natural oscillations of the same periodicity and damping are excited in oscillation circuits 5a and 5a′ by the natural oscillations in antenna 1a, and these oscillations would produce the same low frequency oscillations in the output circuits 8 and 8a′ of detectors 7a and 7a′ if generator 6a were removed.

Owing to the presence of the continuous wave generated by generator 6a in oscillation circuit 5a the low frequency oscillations in circuits 8a and 8a′ differ just as do the low frequency oscillations in circuits 8 and 8′. Circuits 8, 8′, 8a, and 8a′ are coupled to circuit 11, including a telephone receiver 12, in such a manner that the low frequency oscillations in circuits 8 and 8′ oppose, in circuits 8a and 8a′ oppose and in circuit 8 and 8a oppose. As a consequence, the effects due to natural oscillations in antenna 1 and 1a oppose and tend to neutralize each other with respect to receiver 12. This neutralization may be made complete by adjustment of the relative amplifying powers of amplifiers 3, 3′, 3a, 3a′. It is desirable for complete neutralization that the damping factor of the natural oscillations in circuits 5a and 5a′ be substantially the same as the damping factor of the natural oscillations in circuits 5 and 5′. This may be practically attained by adjustment of the inductances in these oscillation circuits.

Wireless and the New York Police

Advantages of Radiotelegraphy Demonstrated In Practical Police Work

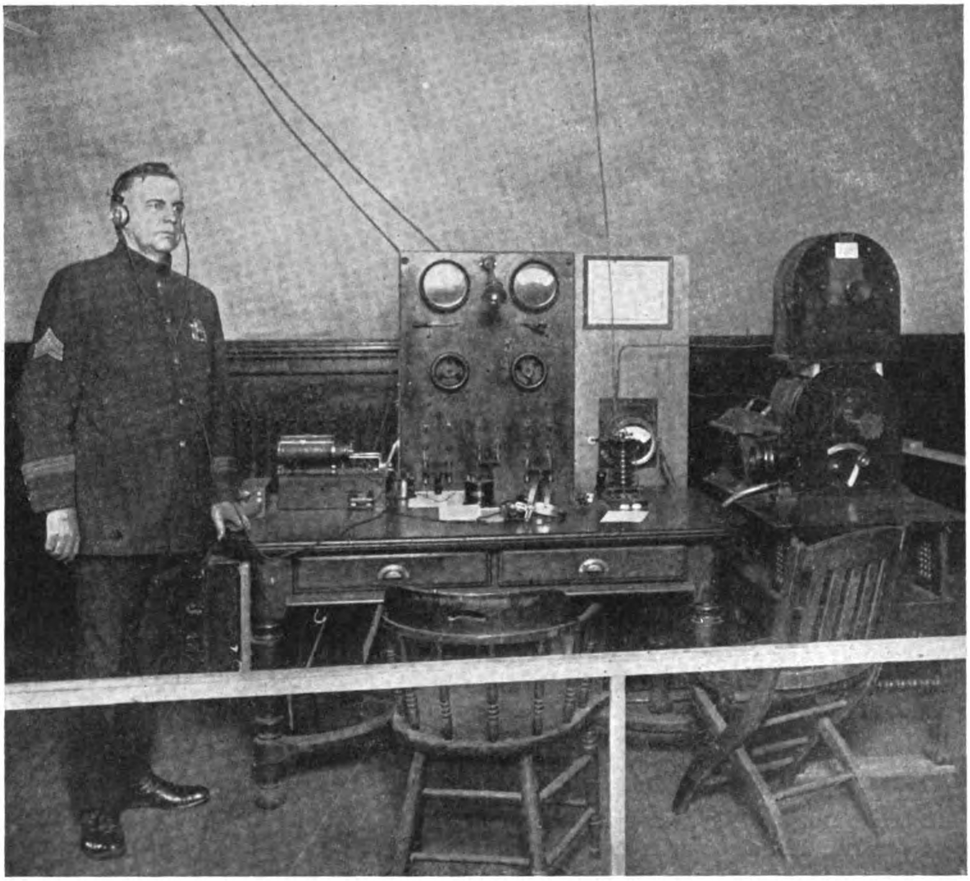
POLICING a city like New York is a large problem, even under normal conditions, but when a great emergency arises, the task is greatly augmented. In other cities where disaster has destroyed for a time the normal conditions of business and social life, it has often been necessary for the local authorities to call on the State militia or the Federal troops for aid in handling the situation. In New York City the necessity to call in such aid is almost eliminated, even in an emergency, because of the foresight of Arthur Woods, former police commissioner, and the late Max F. Schmittberger, who was chief inspector.

In 1915 a "preparedness" program was mapped out, with a view to giving members of the police force practical knowledge of coping with conditions far outside of ordinary police work.

The first problem was to get the members of the force into good physical condition, for which purpose the regular "setting-up" exercises of the army were adopted. During the summer of 1916, more than 3,000 members of the force experienced army camp life, under the supervision of regular army officers. The men were taught the elements of field service in detail, pitching tents, cooking and serving meals, and acquiring a knowledge of sanitation. The Army manual of arms was also taught. At the conclusion of the training period it was announced that, should emergency in the city necessitate the establishing of refugee camps, three thousand members of the police department were in a position to take full charge. The sites for such camps were then selected and arrangements made for their use. All members of the force have been listed according to their former occupations, and since many are skilled it seems that the force will be able to take care of any task that may come up.

Policemen who have had experience in signal work, are prepared to take care of communication matters, should the telephone system fail. In this connection a wireless system has been established with three stations now in operation. Members of the force who have attended the wireless school of the department have passed the government examinations obtaining licenses as first grade radio operators. Considerable extension of the wireless system and an increase in the number of operators are now being worked out. The three department wireless stations, Manhattan Headquarters, Brooklyn Headquarters and the Steamer Patrol, have proven a very useful addition to the communication system. Manhattan Headquarters is equipped with Marconi 1 kw. quenched gap transmitter, and standard receiver, the call being 2ZA. Philadelphia and Albany have been worked. Brooklyn Headquarters' call is 2ZO, has a 2 kw. Marconi synchronous rotary gap equipment, and standard receiver. KIN is the call of the Steamer Patrol, which has a ¼kw. Marconi transmitter with standard receiver.

The three department wireless stations at Manhattan and Brooklyn Headquarters and on the Steamer Patrol have been in operation for ten



Manhattan Police Headquarters Wireless Station. Sergeant Pearce in charge

months and wireless communication between Police Headquarters and the Patrol is proving of valuable assistance in police work on the water surrounding New York. Previous to the installation of the wireless system it was necessary for the boat to tie up at a dock, to enable an officer to communicate with Headquarters or the precinct by telephone. This took considerable time, particularly at night, but now when the boat is away from the pier, and anywhere between Sandy Hook and City Island or Spuyten Duyvil, communication can be instantly established with either Manhattan or Brooklyn Headquarters, and orders given or reports received. Occurrences on the water where police assistance is required, are frequently reported to Harbor A, or Headquarters, by citizens over the telephone. When the boat is at the pier it is sent to investigate, and often sends a report of the case by wireless to the radio man at Headquarters, who telephones it to Harbor A. When the boat is away from the pier such messages are given to the wireless operator at Headquarters, for immediate transmission to the boat.

A few of the many instances in which this quick communication has enabled the rendering of prompt police service are here mentioned. In each case the boat was away from the pier, but communication was effected as quickly and accurately as if connected directly with Headquarters by a telephone line.

Two barges broke away from the pier at the foot of East 54th street on May 18 at 4 a. m., and, driven by a strong wind and tide, they swept up the East River and carried three more away from the 70th street pier. The five barges drifted out through Hell Gate, in the way of the fleet of steamers that come in through Long Island Sound early every morning. The Patrol was off Staten Island when this information was transmitted by the Manhattan Headquarters' wireless station. At 5:35 a. m., Sergeant Ellis, in command of the Patrol, reported by wireless that he had found and docked four of the barges, and that the fifth had been secured by a tug.

A fire occurred in the Metropolitan Hospital on Blackwell's Island about 1 o'clock in the morning of May 21. The Patrol was cruising around the lower bay at the time, when it received orders by wireless to proceed to the fire and to stop at the East 51st Street pier, for the Battalion Fire Chief. When the fire was extinguished, wireless orders were given the boat to resume patrol.

Richmond Telegraph Bureau, on May 26, at 3 p. m., notified Harbor A of a fire on board a Municipal ferry boat, bound from New York to St. George. The information was wirelessed to the Patrol in the East River, and at 3:39 p. m. it was reported by wireless that the fire had been extinguished with slight damage.

The Brooklyn Telegraph Bureau was notified by a citizen on June 5, at 4:35 p. m., that a motor boat off Manhattan Beach was flying distress signals. The Brooklyn wireless operator sent the message to the Patrol, which was off the Navy Yard. The police boat immediately started to the rescue, and at

Wireless room on the steamer "Patrol" of the New York Police Department. Patrolman John Ward

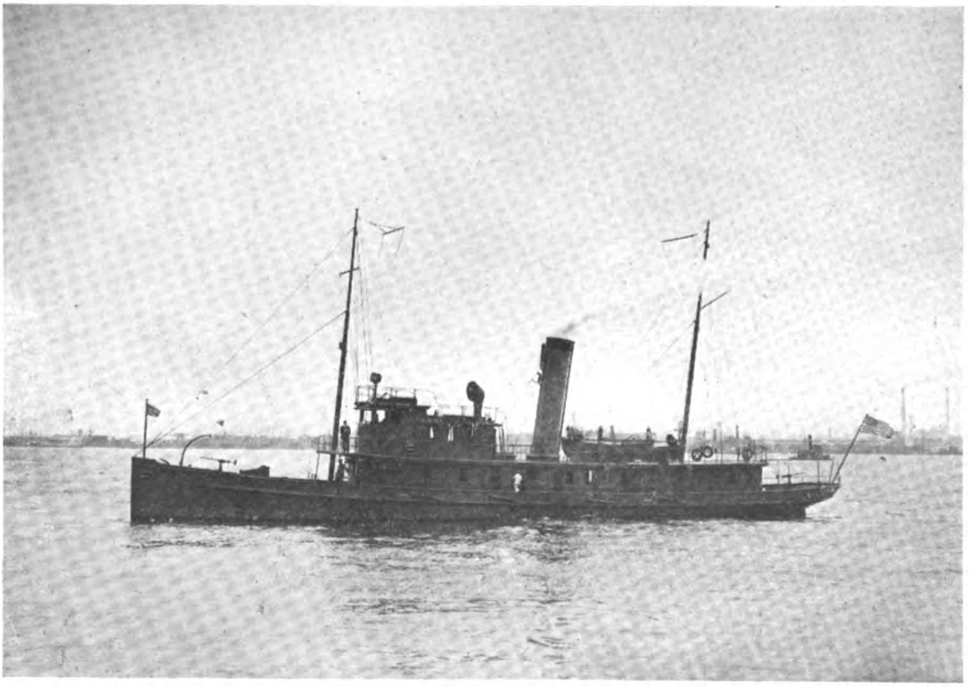
5:16 p. m., the commanding officer inquired by wireless if any further information had been received. The Brooklyn Bureau, after communicating with the citizen who reported the matter sent the following message to the boat at 5:28 p. m.: "Party in motor boat off Manhattan Beach still waving white flag. Coney Island Life Corps tried to reach them and failed." The Patrol reached the location at 6:15, just as the launch was taken in tow by a fishing steamer.

On June 13, at 10:30 p. m. a citizen notified Richmond Telegraph Bureau that a large transatlantic steamer was sinking as a result of a collision with another boat in The Narrows. The Patrol was ordered to the scene by wireless, and at 12:15 a. m., transmitted a full report of the accident to Headquarters by wireless.

A schooner which had grounded near Ellis Island in the evening of June 17, floated at high tide and drifted up the Hudson River, with no one on board. Harbor A was notified by telephone, and relayed the message through Manhattan Headquarters' wireless station. Twenty minutes later a wireless report was received from the Patrol that the schooner had been anchored and lighted.

Harbor A was notified by the pier watchman on June 20, at 9:40 p. m., that a lighter had broken away from the West 30th street pier, and was drifting up the river. The Patrol, then off the Statue of Liberty, was notified, and at 10:15 p. m., reported by wireless that the lighter, carrying a cargo of coffee valued at $50,000, had been returned to the pier.

A report was received at the Brooklyn Telegraph bureau on July 3d, at 5:25 p. m., that some people in a rowboat off Coney Island were being carried out to sea. The report was transmitted to the Patrol by the Brooklyn wireless operator and the police boat started for the scene. At 5:32 p. m.,



Steamer "Patrol" of the New York Police Department

the Brooklyn bureau was notified that the rowboat had been picked up, and this information being wirelessed to the steamer an unnecessary trip was avoided.

On the national holiday, July 4th, Harbor A was notified by a citizen at 6:45 p.m. that a tug was churning up and down the East River, apparently not under control. It had been in collision with other boats. The Patrol was sent to investigate and found that two intoxicated boatmen had stolen the tug Gen. I. J. Wistar, from a pier in Brooklyn, and were having a "joy ride." The men were arrested. The case was reported by wireless at 7:50 p.m., the tug being returned to the owners but slightly damaged.

Trouble on a steamship anchored in the harbor was reported by telephone to Harbor A, on July 13, at 1:50 p.m. The Patrol was sent to investigate and it was found that a number of the crew of the steamship had been seriously stabbed during a brawl. A wireless message for an ambulance to meet the Patrol at Pier A was sent to Manhattan Headquarters at 2:10 p.m. The injured man, who subsequently recovered, was brought ashore ten minutes later and sent to the hospital in the waiting ambulance. His assailant was arrested and held.

A three-alarm fire occurred on August 20, at 3:07 a.m., at the foot of Congress Street, Brooklyn. The Patrol attended the fire, and at 5:05 a.m., sent the following report by wireless: "Fire on pier 26 under control. Steamer Barrentjetberg towed out from pier while in flames and anchored northeast end of Governor's Island, where fire was extinguished by steamer Patrol and tugs."

On August 26, at 6:50 p.m., Harbor A received a report by telephone that three coal barges were adrift in the East River, off East 10th street. The Patrol investigated, and three hours later reported by wireless that the barges had been docked at East 8th street, where they belonged.

The patrol has had the honor of conveying from its landing in Jersey City to New York, each of the six foreign Commissions that visited this country during the summer. On these occasions, use of the wireless equipments between the boat and headquarters enabled the city officials to keep in close touch with the movements of the parties. When a train with the Commission was late, Headquarters was informed by wireless from the boat which was waiting at Jersey City, and when the party boarded the boat, a wireless message to Headquarters was relayed by telephone to the Inspector in charge of the line of parade, so that the route could be cleared in time, with the least interruption of regular traffic. Altogether about 900 separate messages were exchanged between the three department wireless stations, during the first six months of 1917.

Finding Your Way Across the Sea

The urgent demands upon Captain Uttmark to prepare officers for sea duty has required this author to give almost his entire time to Government service. For this reason he has been unable to prepare the article of his series for this issue before it went to press. The March issue, however, will contain the lesson omitted.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

NINTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Radio Apparatus of the Signal Corps—Part Three

IN THE January issue the U. S. Army Signal Corps radio pack set, 1913 type, was described and instructions for its operation given. In general the same instructions given for it apply to the 1915 set, which consists of the following *units*:

1 operating chest.
1 hand generator.
1 mast.
1 pack frames, set (3 frames).
1 tent.

Each *unit* contains *component parts* as follows:

Operating chest:
1 chest.
1 resonance transformer.
1 condenser.
1 oscillation transformer.
1 sending key.
1 spark gap.
1 hot-wire ammeter.
1 switch.

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

1 receiving set.
1 connecting cord, for generator (4-conductor, with plugs).
1 connecting cord, with plug, for antenna.
1 double-head receiver.
1 test buzzer.
1 tool kit.
1 extra section for transformer secondary.
1 extra set crystals.
1 canvas case for receiver.
1 connector, 4-wire (lower half) generator.
2 connectors, 2-wire (lower half), antenna and counterpoise.
1 flexible connector for antenna inductance.
1 connector, 2-wire, small, for receiving set.
2 spring hooks.
4 legs for chest.

Hand generator:
1 generator.
2 cranks.
1 stand.
1 speedometer (carried in operating chest).
1 cap for speedometer opening.
1 canvas hood.

Mast, type F. (Type D mast has 1 top, 1 bottom, 5 intermediate and 3 extra sections):
1 top section.
1 bottom section.
8 intermediate sections.
4 intermediate sections, extra (3 for tent).
1 antenna.
1 counterpoise.
9 carriers, wire.
4 pins, antenna.
2 hammers.
1 set adapters for tent (4 pieces).
1 bag, antenna and counterpoise.
1 bag accessories.

Pack frames, set:
3 frames (1 set). Each frame is complete with cincha, 2 cincha straps with rings and snap hooks, and 2 straps with snap hooks at each end.

Tent:
1 tent.
14 pins.
2 guy ropes.
1 insulating. device.

Complete sets should be designated as *"radio pack sets, complete,"* giving *year* and *serial number,* and should be so carried on property returns, invoices, and shipping manifests.

Incomplete sets should not be so designated, but *units* in them which are complete should be designated as under the *unit* heading above and *units* that are not complete should be designated as under the *component part* heading. When *units* or *component parts* are used to complete sets they should be expended.

Operating chests and hand generators should always be designated by the *year* and *serial number*, and masts by the *type letters*.

The essential differences in the two models are in the hand generator, the transmitting oscillation transformer, and the receiving set, a brief description of which will be given.

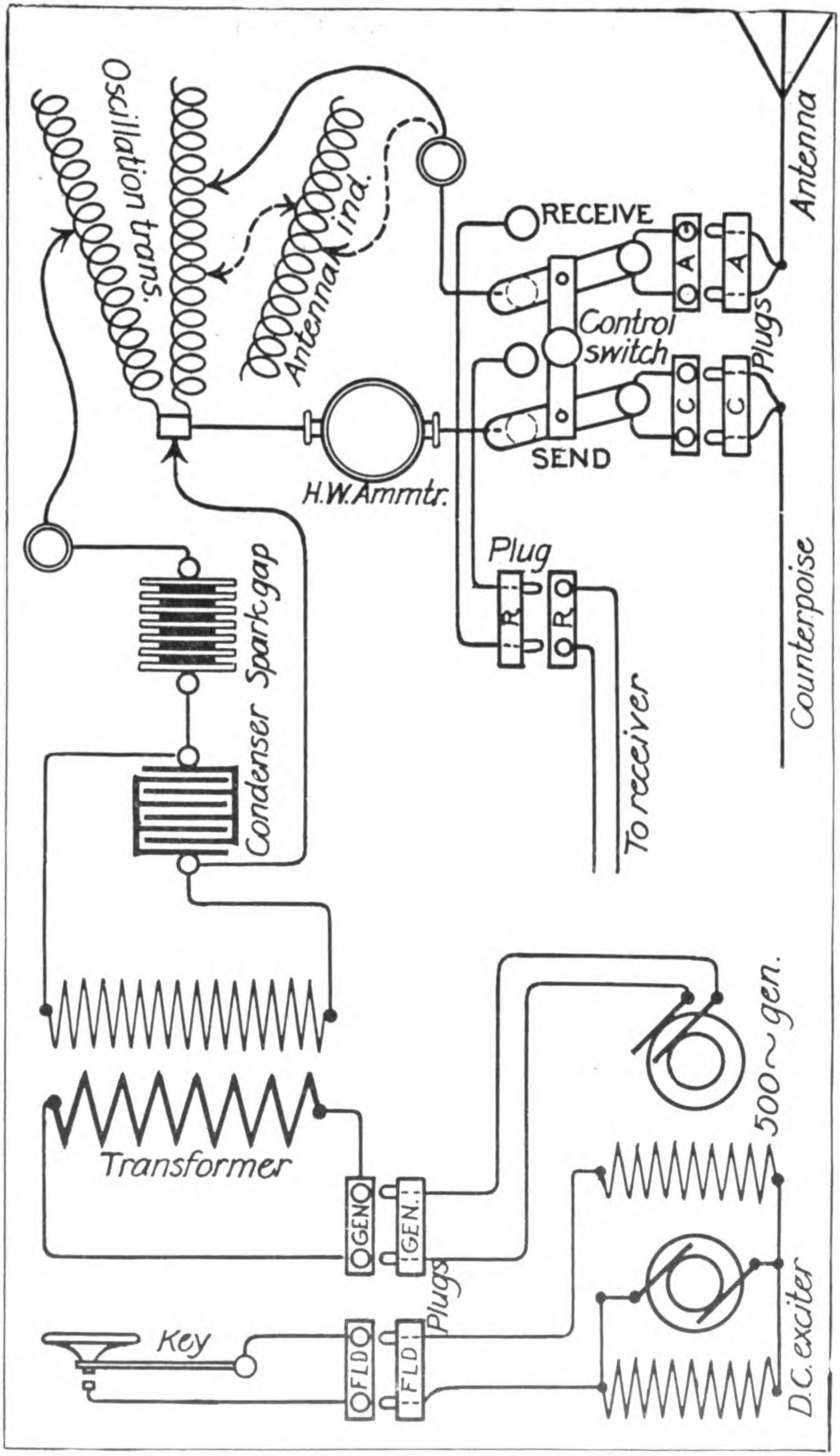


Figure 1—Wiring diagram, radio pack set, Model 1915

HAND GENERATOR

The 1915 generator is a 24-pole machine, with a speed of 5,000 R. P. M. The ratio of the gearing is 100 to 1, as in the 1913 machine, so that the speed of the handles must be 50 R. P. M. At this higher speed less pull is required on the handles and the tiring effect on the men is less than at 33 R. P. M. of the other machine.

On account of the higher speed, great care must be taken to keep the D. C. commutator clean and the brushes properly fitted to it. Failure of a machine to generate current is almost always due to a dirty commutator.

Only a nonfluid oil should be used for lubrication of the gears and ball bearings, and in the same quantity as in the 1913 machine.

OSCILLATION TRANSFORMER

The oscillation transformer consists of two open spirals inductively coupled and a third spiral which is to be used as an antenna inductance for obtaining longer wave lengths. This inductance is inserted between the oscillation transformer and the antenna by transferring the long flexible lead from the open circuit spiral to the inductance which is in turn connected to the oscillation transformer by a short flexible connection. Care must be taken to see that these added turns do not oppose the turns of the oscillation transformer; that is, the inside turns of one should be connected to the inside turns of the other.

Ordinarily the antenna inductance will not be in the circuit except a few inches from the lid of the chest.

The wiring diagram is shown in figure 1, in which the heavy wave lengths, and the dotted lines from it to the antenna inductance and antenna are for the longer waves.

The open and closed circuits of the oscillation transformer are electrically joined together at their base, to which the counterpoise is connected through the control switch and ammeter. This method of construction reduces the number of movable contacts from four to two and also has the advantage that the outside metal rings may be handled without danger of shock.

To put the set into operation: Connect the "Gen," "Fld," etc., plugs into the corresponding sockets; connect the short flexible wire from the rear binding post of the closed circuit condenser to the small angle piece extending out at right angles from the base of the oscillation transformer; connect the long wire at the opposite end of the condenser to the primary or closed circuit spiral, inserting the number of turns corresponding to the desired wave length, counting the turns from the outside turn inward; connect the wire from the control switch to the open circuit spiral, the exact number of turns to be found later by trial. The other end of the spiral is already connected to the counterpoise through the antenna ammeter.

In tuning the circuits the two spirals should be swung apart from 8 to 10 inches. After the two circuits have been brought into resonance, as indicated by the greatest deflection of the hot wire ammeter, the coupling of the two circuits should be increased or made tighter by gradually swinging the spirals closer together until the ammeter deflection just begins to decrease. If a wave meter is available or a distant station assists in the test, a single wave length or "hump" should be radiated and a clear note obtained, the number of gaps being adjusted if necessary as previously described. Care should be taken not to have too close a coupling.

When the standard closed-circuit condenser and oscillation transformer

Members of U. S. Signal Corps attaching support for wireless pole to the new auto radio truck

are used the wave lengths are very approximately given in the following table:

Wave lengths of primary or closed oscillating circuit

Wave length, in meters:	Number of primary turns.
300	2
400	3½
500	5
600	6½
700	8½
800	10
1,000	15
1,200	22

Note.—Turns counted from the outside turn inward.

RECEIVING SET, TYPE C

In the earlier sets, types A and B, the two circuits were magnetically coupled, that is, the current in the primary (open or antenna) circuit induced currents in the secondary (closed or detector) circuit by means of magnetic lines which passed from the primary coil through the turns of the secondary coil. In the present set the two circuits are *statically* coupled; that is, the current in the primary circuit induces current in the secondary circuit by means of static lines in two coupling condensers connected in the leads between the circuits. The transfer of the energy from the primary to the secondary circuit for the operation of the detector and telephones is as efficient in this type of connection as in the other. By choice of suitable values of the coupling condensers *no movement of the coils or changes in coupling* is necessary for the reception of any wave lengths

within the range of the set, as is the case in the former sets. This reduces the number of adjustments for tuning from 4 to 3, and at the same time the set is much more rugged, as there are no moving parts. The values of the coupling condenser have also been so chosen as to make the set much more selective than the others; that is, it can receive signals from a station on one wave length and cut out signals from another station on a different wave length more completely than before. In addition to the above advantages, the set as a whole has been found to be more efficient than the previous types.

The type C receiving set consists of two statically coupled circuits, high-resistance telephones, stopping condenser, fine wire-galena detector, switch for short and long wave lengths, three dial switches for tuning, etc. The circuits are shown diagrammatically in figure 2.

The primary circuit consists of: (1) The antenna, which when the control switch in the cover of the chest is thrown to the "Receive" position, is connected by a double plug with flexible wires to the binding post on the set marked "A"; (2) two primary coils in series, one large and the other small, the number of turns in both of which is variable by means of the two dial switches marked "Primary." On each coil there are contacts, 0 to 24, for tuning to different wave lengths, the dial nearest to the binding post "A" being connected to the large primary for large changes in wave length and the other to the small one for small changes and fine tuning; (3) counterpoise which is connected to the binding post marked "C" through the double plug and control switch. There is no series condenser in the antenna circuit for the reception of wave lengths shorter than the fundamental wave length of the antenna, as in types A and B, as it has been found not to be generally useful.

When comparatively short wave lengths are to be received, as from 300 to 700 meters, the double-pole double-throw switch on top of the set should be thrown to the position marked "Short." This makes no changes in the primary circuit, but connects into circuit (1) the secondary coil with the dial switch marked "Secondary," with contacts 0 to 24 for tuning to different wave lengths; (2) detector and telephones.

Short wave signals should be picked up by adjustments of the large primary and the secondary dials and fine adjustments made later on the small primary dial.

When longer wave lengths are to be received, as from 500 to 2,400 meters, the D-P-D-T switch should be thrown to the "Long" position. This makes no changes in the primary circuit, but disconnects the secondary coil, which in this set is most useful only at short wave lengths, and connects the circuits as shown in the second print. As the secondary coil is not in circuit, only the two primary dials are effective in tuning.

Long wave signals should be picked up only by adjustment of the large primary dial and fine adjustments made later only on the small primary dial.

RECEIVING SET, TYPE D

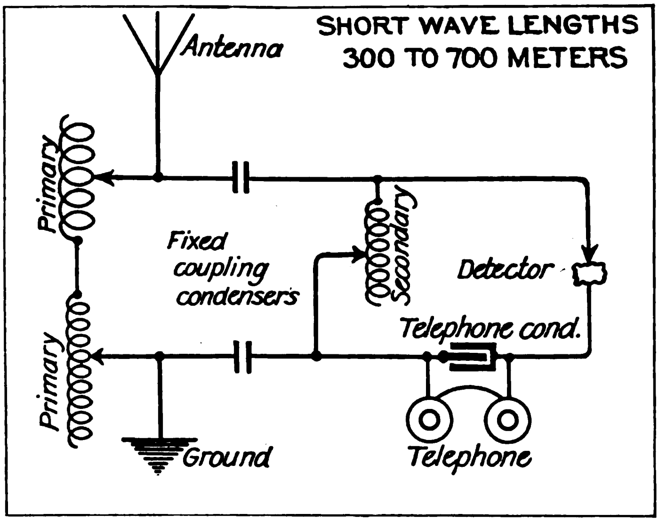
This set is practically the duplicate of the type C, except that the number of studs in the three dials has been increased so as to give finer tuning.

TRACTOR SETS

The Signal Corps has designed and built two sizes of automobile radio sets, or tractor sets, as they are called—(*a*) a "divisional" tractor of 1 k. w. size; (*b*) an "Army" tractor of 2 k. w. size.

The 1 k. w. set, complete with supplies and detachment of seven men, weighs about 6,700 pounds, and on an average road is capable of making a speed of from 20 to 25 miles per hour. It carries a 60-foot sectional mast,

which can be raised in a few minutes by means of guides on the roof of the tractor. The antenna is of the umbrella type, with 16 radiating wires each 75 feet long. The counterpoise is likewise of the umbrella type, laid on the ground with 8 wires, each 75 feet long. The transmitting set is of the quenched-spark type, with inductively coupled circuits adjusted to radiate waves of 600, 800, 1,000, and 1,200 meters. The receiving set is of the statically



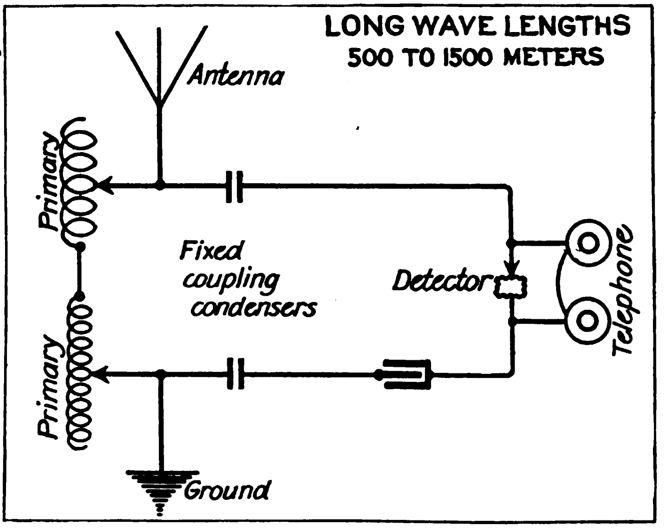


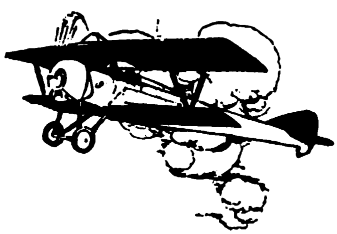
Figure 2—Type C Receiving Set. Diagrammatic circuit

coupled type similar to that in use in the 1915 radio pack sets, but of larger size and capable of reception of much longer wave lengths.

The 2 k. w. set, complete with supplies and detachment of eight men, weighs about 9,000 pounds, and on an average road is capable of making a speed of at least 15 miles per hour. It carries an 80-foot sectional mast, which is raised in a manner similar to that in the 1 k. w. set. The transmitting and receiving sets are likewise similar to those in the previous set, but capable of using much longer wave lengths.

How to Become an Aviator

The Seventh Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

THE careful student of this series has learned thus far the whys and wherefores of aeroplane design, i.e., the fundamental factors that make for flight efficiency. Thoroughly grounded in these principles, practical rigging of the machine may be turned to in full confidence of doing a good job. Reasonable familiarity with the use of simple tools but remains to be acquired; this is a short process of practice in their handling, the keystone of success being the exercise of care. If the preliminary study has been conscientious up to this point, the reason for each step in assembly will be clear without explanation and the requisite exactness will follow as a matter of course.

Golden Rules of Rigging

Don't hurry. If the job is a rush one, make haste slowly.

Never lay tools on the planes.

Pliers or wrenches are not for use on aeroplane bolts; a burred thread, or one damaged in any way, should be discarded.

Turnbuckles are to be started from both ends.

There should be a cotter pin for every nut and safety wires should lock all pins and turnbuckles.

Wire with a kink in it should be brought to the attention of some one in authority.

Don't hammer or pound bolts and pins into position; they must go into place by pushing or gentle tapping.

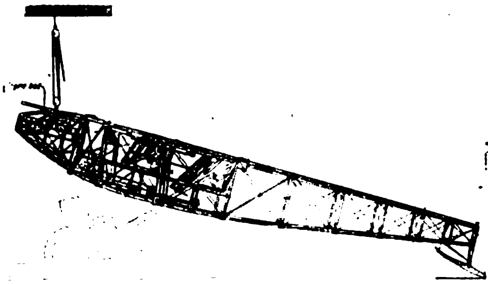


Figure 32-a—Method of attaching landing gear

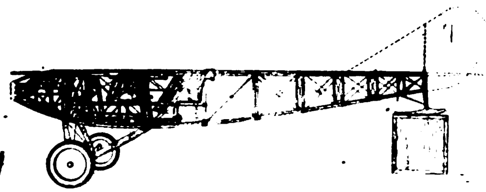


Figure 32-b—Method of attaching horizontal stabilizer

ERECTION AND ASSEMBLY.

An assembled aeroplane is a trim and fairly hardy machine, but before assembly the parts are fragile. When received, the greatest care should be exercised in unpacking boxes and crates.

The order of assembly and directions follow:

Landing Gear—Mount the wheels on the axle and bolt them into place. Connect up the tail skid by pinning the front end to the spring fitting and the other end to the socket of the tail post. Now raise the fuselage to receive the landing gear. This may be accomplished by blocking, or by tackle as shown in Figure 32-a, where a line is passed under the sills of the engine bed —nowhere else—and caught by the hook of the hoisting block. Raise the front end of the fuselage until the lower clips of the longeron line up with the clips on the ends of the landing gear struts. The bolts are then passed through the aligned holes and the nuts drawn up tight. Cotter-pins are inserted in the holes drilled through the bolt, which then appear just beyond the castle of the nut. The leaves of the cotter-pins are turned backward, locking the nuts in place The gear should then be aligned in accordance with instructions on the second page following.

Horizontal Stabilizer—With the landing gear attached to the fuselage, elevate the tail of the machine, supporting it on a horse of proper height, or block until the upper longeron is level, verifying the arrangement by use of a spirit level placed on the upper longeron at the tail. See Figure 32-b. Bolt the horizontal stabilizer to the top longeron and tail post and draw all nuts tight and secure them with cotter-pins.

Vertical Stabilizer—Fasten the vertical stabilizer by bolting it through the forward part of the horizontal stabilizer and the clip at the front of the vertical stabilizer; tighten nuts and lock with cotter-pins. A double clip in the rear passes over the two bolts which fasten the horizontal stabilizer to the tail post. Attach the flexible wire cables and tighten by the turnbuckles.

Rudder—Attach the control braces so that the upper tips point toward the line of the hinge. Mount the rudder on the tail post and vertical stabilizer and insert the pins in the hinges, securing them with cotter-pins.

Elevators—Attach the control braces in the same manner as with the rudder and mount the elevators on the horizontal stabilizer by means of the hinges and pins, the latter being secured by insertion of cotter-pins in the holes drilled for that purpose.

(c) Committee on Public Information

Figure 33—Assembly of center section

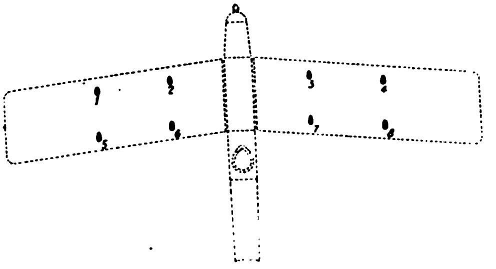


Figure 34—Curtiss strut numbering

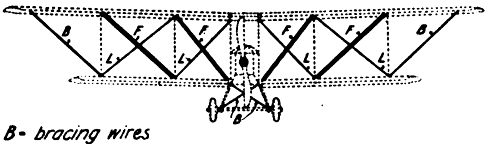


Figure 35—Method of wiring

ASSEMBLY OF LIFTING SURFACES

Center Section—The section of wing surface first attached is that which is directly over the fuselage and known as the engine section panel. With the struts fitted into the proper sockets of the wing surface, the entire section, with bracing wires attached is lifted and set into the sockets on the upper longeron. Bracing wires are then attached and the section aligned.

The method is clearly shown in the photograph, Figure 33

Main Wing Sections—While the upper lifting surfaces may be first assembled to the engine section and the lower wing then attached, it is preferable to complete assembly of the sections, or panels, before attaching them to the fuselage. The advantage of the latter method is that less adjustment is required and the correct stagger and dihedral is secured.

Figure 34 shows the numbering of struts on the Curtiss JN-4. These may be quickly committed to memory by noting that the four struts of the center, or engine section panel are not designated, and that beginning at the left from the pilot's seat, the eight remaining struts are numbered from 1 to 8.

The main struts bear a number and can easily be read from the pilot's seat; it is therefore at once evident if, through error, a strut is inverted.

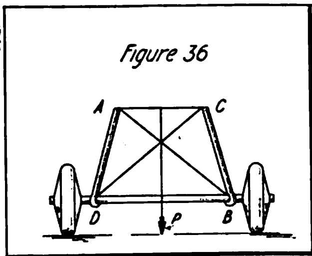
Assembly—The upper wing of the left lifting surface receives struts Nos. 1 and 2 in the proper sockets. The wires are then connected to right and left by clips and adjusted by turnbuckle until the spars are straight. The wing is then set on a cushioned block, leading edge down.

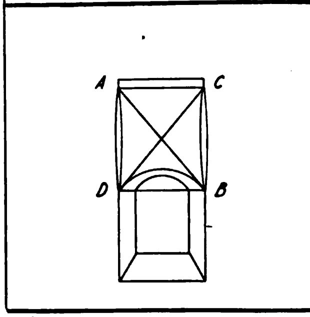
The lower left wing is then brought, leading edge resting on cushioned block, to a space equal to the length of the struts. Diagonal wires are loosely connected and the spars inserted in their sockets, 5 and 6, and bolted into place.

The "landing," or single, wires and the "flying," or double, wires of struts 1 and 5 are then connected closely, so the wings may be held together while being attached to the fuselage.

Figure 35 clearly indicates the wiring of the assembled aeroplane wings.

The erection of the wing must be done with special care. Lifting by the struts or edges of the wings may result in a serious strain. Boards placed under the beams of the wing framework should be used for carrying.





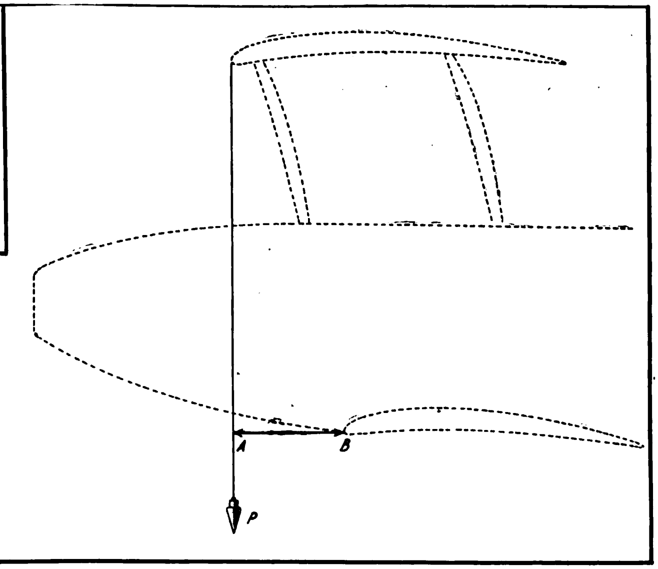


Figure 37a

Figure 37b—Stagger alignment

ALIGNING THE AEROPLANE

Correct alignment of an aeroplane is of tremendous importance. Its flying efficiency depends largely upon exactness in truing up all controls and wires and securing proper angle of incidence and dihedral. The parts should be aligned in regular order as follows:

Landing Gear—To be aligned before wings are attached to fuselage. The axle should be parallel with the lateral axis of the fuselage. Ascertain the exact center of the fuselage and the axle; with spirit level align the cross width of the fuselage. Drop a plumb line from the center of the fuselage and adjust the cross wires until it is in the exact center of the axle.

Or, if plumb bob and line are not available, adjust the cross wires so that the measurement **A-B** is exactly equal to the measurement **C-D** in Figure 36. The adjustment is made on both front and rear supports of the under carriage.

The landing gear and fuselage are aligned in the factory, but their correctness should be determined by the method just given. Before aligning, it is well to verify that the tail support still holds the fuselage horizontal.

Center Section—The bracing wires (**A-B, C-D,** Figure 37-a) are left sufficiently tightened to keep the struts straight, while the wings are being aligned.

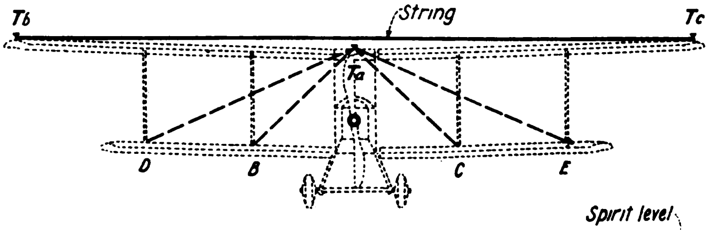
Without Stagger—The upper longerons of the fuselage being horizontal, the struts are properly placed when they form a right angle. Adjust the sides first and then the front. Check the perpendicular alignment by measuring off an equal distance on the upper longeron back and forward of some point on the bottom of the strut; the strut will be exactly perpendicular when the distance from these two points to the top of the strut measures exactly the same. Tighten bracing wires evenly until sides and front are correctly aligned; i. e., until the measurement of corresponding points on cross wires are identical.

Staggered—The angle of strut fittings and sockets serves as a guide to the degree of stagger. The aeroplane's specifications state the stagger; for example in the Curtiss JN-4 it is 10⅝ inches. This is checked by a plumb line suspended from the leading edge of the top surface, as in Figure 37-b, and the measurement is taken between points **A-B;** that is, the plumb line should be 10⅝ inches in advance of the leading edge of the lower wing.

In all types of aeroplanes the specifications state how the measurement should be taken (a) along the line of the chord, or (b) horizontally.

When the stagger is verified, the wires should be tightened and the cross distances measured until one side corresponds exactly with the other. Side wires should be adjusted first, and then the front, and cross distances measured until they correspond exactly.

Main Wing Sections—The first point to determine is whether leading edges of the upper and lower wing surfaces are exactly in line with the center section. Standing on a step ladder, 15 feet to one side, a sight by eye is taken along the leading edge of the upper plane. If not straight, the adjustment for warp or bow is made by tightening or loosening the front landing wires. The same should then be done for the lower plane and the opposite wing aligned in the same manner. When the cross wire adjustments have been completed, a sight taken from both ends of the wings should show all struts in line and parallel with the center section struts.



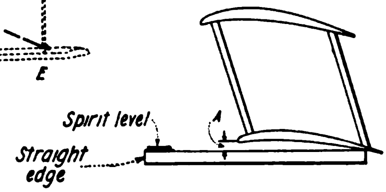


Figure 38—Dihedral angle measurements

Figure 39—Angle of incidence

DIHEDRAL ANGLE

One method of securing the dihedral angle is shown in Figure 38, where **Ta** is a tack placed in the exact center of the center section, on the leading edge of the upper wing. The exact distance is measured off then on each side and tacks, **Tb, Tc,** placed in the leading edge of both upper wings, at a point near their tips. A string is stretched tightly between **Tb** and **Tc.** The specifications are then referred to and the dihedral angle checked. Assuming the dihedral angle to be 176 degrees, then each wing has been raised 2 degrees. The natural sine of 2° being 0.0349, this, multiplied by the distance between **Tb** and **Ta** (or **Ta** and **Tc**) gives the proper distance between **Ta** and the string directly above it.

Example:

The distance **Tb-Ta** (or **Ta-Tc**) is 16 feet=192 inches.

192 in.×0.0349=6.7 in., or the proper distance between **Ta** and the string above, if wings are set at the proper dihedral.

In making the alignment, the wings should be raised equally until the correct measurement over the center section is secured. Care should be taken that the leading edges are kept straight.

All adjustments should be made by altering the wires from the inside bays; when diagonal wires are to be tightened make sure that the opposite wires in the same bay are slackened off.

Check up the alignment by measuring (Figure 38) from **Ta** successively to points **D, B, C, E,** making certain that the distance **Ta-B** corresponds with **Ta-C,** and **Ta-D** is the same as **Ta-E.** This will show that both wings are the same height.

ANGLE OF INCIDENCE

The specifications give a set measurement for the angle of incidence. Verify the horizontal position of the top longeron of the fuselage, i. e., make certain that the aeroplane is in flying position. Then place the straight-edge underneath the center of a rear strut as shown in Figure 39. With a spirit-level, adjust the straight-edge to horizontal position. Refer to the specifications and note the set measurement given; this will require measurement from

A—the lowest part of the leading edge to top of the straight-edge, or

B—the center of the front strut to the top of the straight-edge.

This measurement must be repeated under every strut, or the lower surface where struts occur.

The measurement should not be made between struts, because the wings may be slightly warped.

If the angle is too great:

Slacken all the wires attached to the top of the rear strut and tighten all the wires attached to the bottom.

If the angle is too small:

Slacken all wires attached to the bottom of the strut and tighten all wires attached to the top.

The correct adjustment, laid down in the specifications, should be made with no greater variation than 1-16 inch. The measurements at all struts must agree, i. e., the angle of incidence all along the wing must be the same, unless the wings have a washout or washin.

Check up the stagger with a plumb line to see that it has not been disturbed while securing the dihedral.

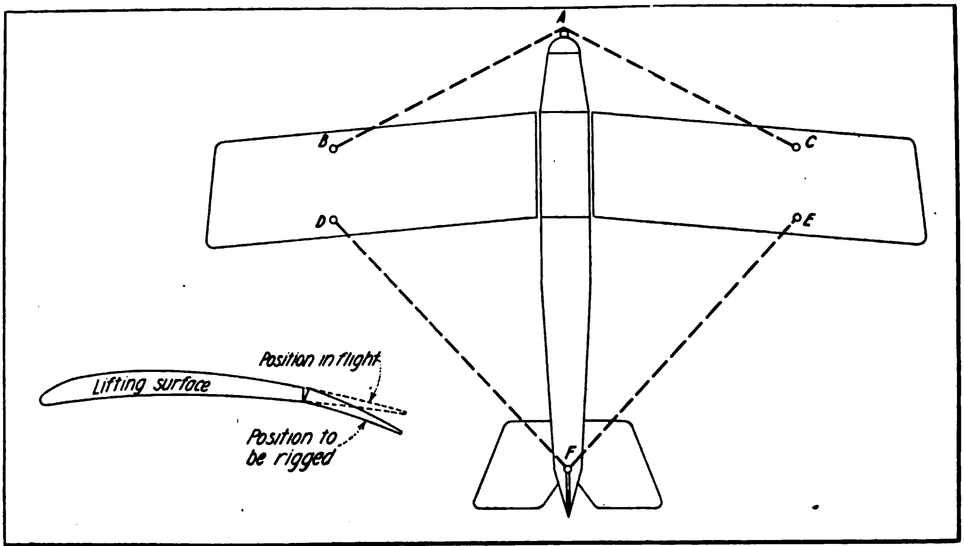


Figure 40—Aileron rigging *Figure 41—Over-all check*

DROOP

When the angle of incidence and the stagger have been adjusted, one wing must be slightly drooped to correct for the torque of the propeller, where a single propeller is used in tractor aeroplanes.

With a propeller that turns to the right (clockwise) the left wing is drooped. If it turns to the left the right wing is drooped.

For machines up to 100 horsepower, the outer rear landing wire of the wing which is to be drooped is slackened until the trailing edge between outer and intermediate struts is about 1 inch lower than the rest of the trailing edge.

CONTROLLING SURFACES

Since the pilot depends upon the manipulation of controlling surfaces to manage his aeroplane, exceptional care should be taken that ailerons, elevator and rudder are properly rigged.

Ailerons, Trailing Edge (wing flaps)—With the control levers rigidly blocked into neutral position, the aileron should be rigged so its trailing edge is about ¾ inch below the trailing edge of the surface to which it is attached. In flight the angle of incidence of the surface will cause it to lift a little above the position, or to the true line. This is illustrated in Figure 40 where the dotted outline shows the position during flight.

A basis of measurement commonly used is ½ inch depression for every 18 inches of chord of the controlling surface.

Tail Stabilizer—With the weight of the tail supported by the tail skid, align the rear edge of the stabilizer so it is straight and parallel with the lateral axis of the aeroplane. Take a sight from the rear to the leading edge of the upper plane, which should be in alignment with the trailing edge of the stabilizer. Tighten the wires by turnbuckles.

Elevator Flaps—With the controls in neutral position adjust the control wires by turnbuckles until the elevator flaps are in the same plane, and sufficiently tight to eliminate lost motion.

Rudder—Adjust the control wires by turnbuckle until both foot bar and rudder in neutral position show no lost motion in control.

Over-All Adjustments—Figure 41 illustrates the measurements which are taken as a final check. The measurement **A-B** must equal **A-C** within ⅛ inch. Point **A** is the center of the propeller (in pusher types, the center of the nacelle) and **B** and **C** are points marked on the outer spars equally distant from the butts of the spars. The measurement should be taken from both top and bottom on each side.

D-F should equal **E-F**, within ⅛ inch. The rudder post is point **F**, and **D** and **E** are points on the rear struts marked as in the case of **B** and **C**. Two measurements, top and bottom, are also taken here.

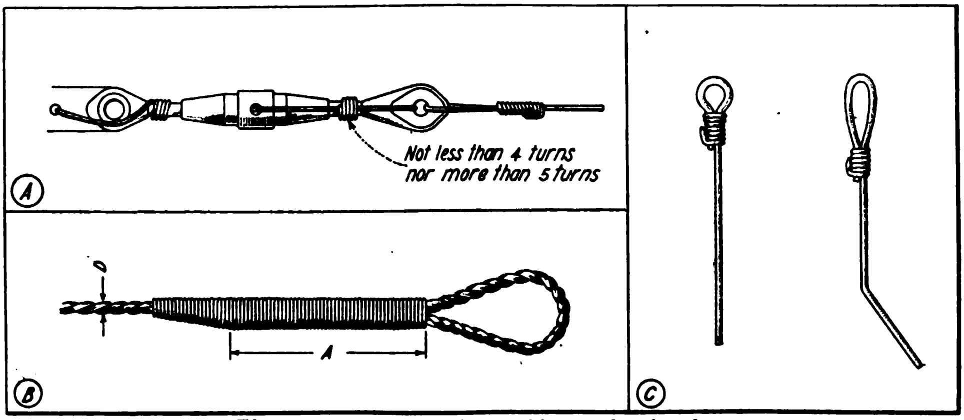


Figure 42—Turnbuckles, cables and wire loops

CONTROL CABLES AND WIRES

Adjustment of Controls—From the pilot's seat move the control levers and note if a quick movement shows lag or snatch in the movement of the control surfaces. Movement of ⅛ inch to either side should produce corresponding motion of the controlling surfaces.

Turnbuckles—The turnbuckle, which is shown in Figure 42-a, is a barrel with an eye-bolt screwed into each end; it is therefore hollow and should not be turned with pliers. It is best adjusted by passing a piece of wire through the hole in the center and using it as a lever. The illustration shows the proper method of using the locking wire, so the barrel may not turn and thereby throw the aeroplane wires out of the fine adjustments required.

Cables—Windings must be even with a stream-lined effect at the end of the winding as shown in Figure 42b. The dimensions of the winding before it tapers off (see **A**, in the illustration) must be at least 15 times as great as **D**, the diameter of the cable. Only non-acid flux should be used in soldering.

Correct Winding for Cables

Size of Cable Inches	Length of winding Inches	Breaking Strength Pounds
1-32	1½	185
1-16	1½	500
3-32	1½	1,100
7-64	1¾	1,600
⅛	2	2,100
5-32	2⅜	3,200
3-16	3	5,500*
7-32	3⅜	6,100
¼	3⅞	8,000
5-16	4¾	12,500

*For cable: loop strength is 5,100 pounds.

Control cables wear and fray out by friction with pulleys; careful examination should be made after each flight, and if a single strand is broken the cable should be replaced.

WIRE LOOPS

Wherever a loop is made with wire to connect with a fitting or turnbuckle it should be symmetrical in shape and reasonably small, with well defined shoulders A loop properly made is shown at the left of Figure 42-c, and one improperly made at the right. Where the shoulder is not properly made and the loop elongated the ferrule is likely to slip up and throw the wire out of adjustment.

When the loop is finished the wire should be undamaged. Wire bent to the degree shown at the lower end of Figure 42-c should be discarded.

TIGHTENING WIRES

Care must be exercised that wires are not too tight or extra loads will be placed on spars and struts. Wires should never be at a tension so they "sing."

THE EFFECT IN FLIGHT OF ALIGNMENT ERRORS

DIRECTIONAL STABILITY

Wrong Angle of Incidence—The aeroplane will turn toward one side if the angle of incidence of one side of the wing surface or tail surface is wrong; for drift increases with greater angle and decreases with lessened angle.

Fuselage, Rudder-fin or Struts Off Line of Direction of Flight—The aeroplane will turn off its course, for unless these are aligned they will act as a rudder.

Distorted Surfaces—The aeroplane will turn off its course if there is an improper bend in leading or trailing edge or spars, for the amount of drift will be changed on one side by increased resistance.

LATERAL INSTABILITY

Wrong Angle of Incidence—If the angle of one wing is greater, more lift will be produced on that side, with corresponding decrease on the other wing. The aeroplane's tendency will then be to fly one wing down.

Distorted Surfaces—The same tendency to fly one wing down will be observed when the camber of the wing surfaces is spoiled by some distortion, through which the lift is made unequal.

LONGITUDINAL INSTABILITY

Wrong Angle of Incidence—If the lifting surface angle is too great the nose will rise through excess of lift and a tendency to fly tail down will result. Too small an angle may cause the aeroplane to fly nose down.

Occasionally, the tail plane's angle of incidence is found to be wrong; the angle should be lessened if the aeroplane is nosing down, and increased if tail-heavy. Adjustments of this kind must be made with care, because longitudinal stability depends entirely on the tail-plane having less angle than the main lifting surfaces.

Fuselage Warped—For the reason given above, a fuselage warped up or down, thereby giving an incorrect angle of incidence to the tail plane, may result in the aeroplane nosing down or being tail heavy.

Wrong Stagger—A nose-heavy aeroplane will result if the top wing is not staggered forward to the correct degree, because the lift will then be too far back. An error of ¼ inch will make a material difference in longitudinal stability. The cause of such error is generally due to the elongation of wire loops or if wires have pulled the fittings into the wood.

FLIGHT DEFECTS

POOR CLIMB

Excepting engine and propeller trouble, the reason for an aeroplane climbing badly is generally due to (1) too small angle of incidence; (2) distorted surfaces.

LESSENED SPEED

Excepting engine and propeller trouble, poor flight speed is generally due to (1) too great angle of incidence; (2) distorted surfaces; (3) skin-friction, from dirt or mud on surfaces.

POOR CONTROL

The main causes are (1) incorrect setting of control surfaces; (2) distortion of control surfaces; (3) control cables badly tensioned.

UNCONTROLLABLE ON GROUND

When an aeroplane will not "taxi" straight the fault is generally due to (1) improper alignment of landing gear, wobbly wheels, or (2) unequal tension of shock absorbers.

The eighth article of this series, which will appear in the March issue, will describe propeller design and maintenance of air-screw efficiency; the aviation engine's principles of operation and its fundamentals of design, including a description of parts and their function in supplying motive power.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE X

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE—This is the tenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

CONTINUOUS AND DISCONTINUOUS WAVES

(1) In general there are two systems of wireless transmission:

(1) The discontinuous wave system,
(2) The continuous wave system.

(2) **Discontinuous waves** are used almost exclusively for ship to ship and ship to shore communication.

(3) **Continuous and discontinuous waves** are employed for transmission at high power.

(4) Continuous wave transmitters have had some slight use aboard vessels, but in general they require an antenna of very large dimensions which only can be erected on very large vessels. It is possible, however, that the vacuum tube oscillators at some future date may be employed to generate continuous waves at the shorter wave lengths say between 600 and 1,000 meters.*

WAVE LENGTH CHANGING SWITCH

(1) It facilitates the transmission of wireless telegraph traffic to provide the transmitter with a specially constructed switch whereby the operator may change instantly the **lehgth of the radiated wave** without going through a series of connections and disconnections in the various circuits. In earlier wireless systems, if the transmitter, for example, was adjusted to 600 meters, in order to radiate a 300 meter wave, the operator was required to

(1) cut out turns at the aerial tuning inductance;
(2) cut out turns at the secondary winding of the oscillation transformer;
(3) disconnect the jumper around the short wave condenser;
(4) reduce the inductance or perhaps the capacity in the closed circuit;
(5) readjust the spark gap voltage for clearer tones;
(6) insert a reactance coil in the primary circuit of the high voltage transformer;
(7) change the coupling between the primary and secondary windings (for maximum antenna current).

(2) With modern Marconi transmitters all of the foregoing changes are effected simultaneously by the simple throwing of a specially constructed switch.

(3) **Commercial marine transmitters** are generally designed to radiate three standard wave lengths,—300, 450, and 600 meters; but obviously, they can be provided with any number of wave lengths. Sets have been constructed to date for the radiation of six and eight different wave lengths.

(4) The advantage derived from this arrangement in practice lies in the fact that if the receiving experimenter is interfered with by another station he may request the transmitting operator to change instantly to another wave length. Thus, the transmitting operator may change the wave length several times during the transmission of a single message, notifying the receiving operator by a special signal in order that he may change the tuning of the receiving apparatus. Traffic may thus be dispatched through severe interference.

(5) A diagram showing the functions of the wave length changing switch in Marconi panel transmitters is shown in Figure 92. Figure 91 is a fundamental wiring diagram which in a general way covers the circuits of any transmitting apparatus for the production of damped oscillations.

*Continuous wave systems will be treated in detail further on.

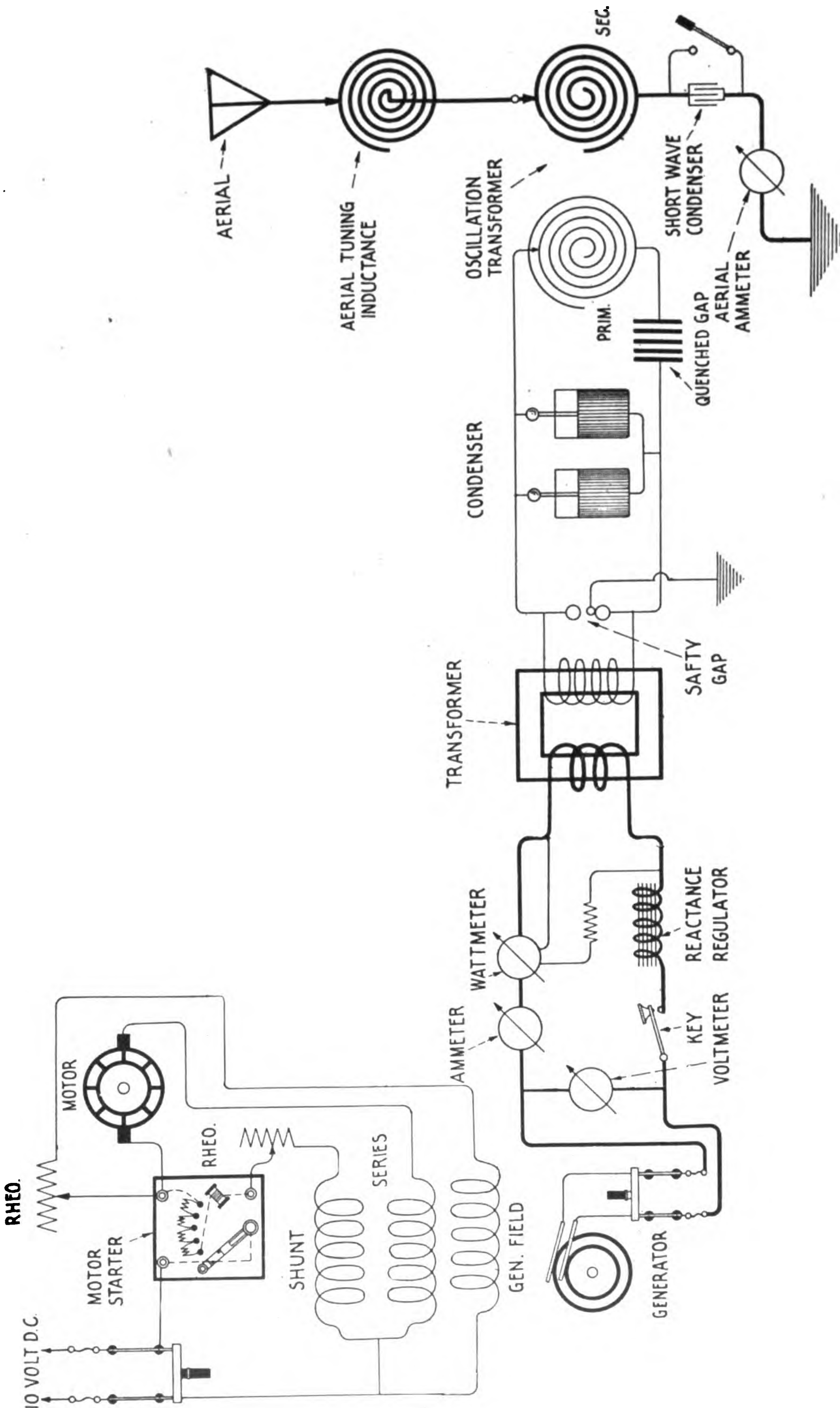

AERIAL
AERIAL TUNING INDUCTANCE
SEC.
OSCILLATION TRANSFORMER
PRIM.
SHORT WAVE CONDENSER
AERIAL AMMETER
QUENCHED GAP
CONDENSER
TRANSFORMER
SAFTY GAP
WATTMETER
REACTANCE REGULATOR
AMMETER
KEY
VOLTMETER
MOTOR
RHEO.
RHEO.
MOTOR STARTER
SHUNT
SERIES
GEN. FIELD
GENERATOR
110 VOLT D.C.

Figure 91

OBJECT OF THE DIAGRAM

(1) To show the fundamental circuits of a spark transmitter for the production of damped oscillations.

DESCRIPTION OF THE DRAWING

The complete transmitting set shown in figure 91 consists of the following apparatus:

(1) A motor generator to convert direct current to alternating current;

(2) A starting box to regulate the flow of current through the motor armature during the starting period;

(3) Field rheostats to regulate the frequency and the voltage of the generator;

(4) A step-up transformer to raise the voltage of the alternating current to a value in excess of 10,000 volts;

(5) An ammeter to measure the current flowing through the transformer;

(6) A voltmeter to measure the voltage at the terminals of the alternator;

(7) A wattmeter to measure the power input to the transformer;

(8) A reactance regulator to regulate the flow of current through the primary winding of the transformer;

(9) A telegraph key to permit the current to be interrupted in the form of the dots and dashes of the Morse code;

(10) A battery of condensers for the production of radio-frequent oscillations;

(11) A spark discharge gap to discharge the energy stored up in the condenser;

(12) An oscillation transformer to transfer current at radio-frequencies from the condenser circuit to the aerial circuit;

(13) An aerial ammeter to determine conditions of resonance between the condenser circuit and the aerial circuit;

(14) A short wave condenser to decrease the wave length of the antenna circuit;

(15) An aerial tuning inductance to increase the wave length of the antenna circuit;

(16) An aerial changeover switch to shift the aerial alternately from the transmitting apparatus to the receiving apparatus;

(17) An aerial to radiate energy in the form of electromagnetic waves.

OPERATION

The apparatus shown in Figure 91 functions as follows: Direct current at pressure of 110 volts enters the motor armature at the starting box setting the motor into rotation. The alternator, in turn, generates alternating current at pressures varying from 110 to 500 volts and at frequencies varying from 60 to 500 cycles according to the design of the machine.

When the telegraph key is closed, alternating current flows from the generator through the primary winding of the high voltage transformer. The flux generated by the primary coil cuts through the secondary coil inducing therein current at pressures varying from 8,000 to 25,000 volts (commercial practice), according to the ratio of the secondary and primary turns.

The frequency of the generator can be adjusted within certain limits by means of the **motor field rheostat.** If **resistance is added** at the **motor field rheostat,** the motor **increases its speed** and accordingly the frequency of the generator increases. This increase of speed also increases the voltage of the alternator. The voltage of the alternator can be reduced by adding resistance at the generator field rheostat. By **cutting out resistance** at the generator field rheostat a stronger magnetic field will result and the voltage of the generator will increase.

The terminals of the secondary winding of the high voltage transformer are connected to the terminals of a battery of condensers in which the energy is stored up temporarily in the form of an electrostatic field. When the charge for each alternation of the charging current has attained its maximum value the condenser discharges across the spark gap through the primary winding of the oscillation transformer. This discharge consists of a number of oscillations of radio-frequency.

The frequency of the oscillations can be changed as follows:

By subtracting turns at the primary winding of the oscillation transformer the frequency of the oscillations increases, or by adding turns at the primary winding of the oscillation transformer, the frequency of oscillation reduces to a lower figure.

A reduction of the capacity of the high voltage condenser increases the frequency of the oscillations, but an increase of capacity lowers their frequency.

When the closed circuit is set into electrical oscillation, it acts inductively on the secondary winding of the oscillation transformer setting up in the aerial wire currents of similar frequency, and a portion of their energy is radiated from the aerial in the form of electromagnetic waves. In a single wire aerial system, the wave length of the resulting wave motion is approximately 4.3 x the length of the oscillator, but in the case of a multiple wire aerial, the **natural frequency** of oscillation is determined from knowledge of its inductance and capacity.

The length of the radiated wave, in fact, varies inversely as the oscillation frequency. The higher frequencies such as 500,000 and 1,000,000 cycles per second correspond to waves 600 meters and 300 meters respectively. The lower frequencies of oscillation, for example, from 30,000 to 100,000 correspond to the longer waves from 10,000 meters down to 3,000 meters.

In order that the radiated wave may be detected at the receiving station there must be erected a receiving aerial fitted with tuning appliances to adjust it to resonance with the **natural frequency of the transmitter aerial.** Then, by means of proper oscillation detectors (of which there are various types), these high frequency currents are converted into currents of audiofrequency suitable for response in a receiving telephone.

By interrupting this wave motion to imitate the dots and dashes of the telegraph code, the radiated energy will act inductively at intervals upon the receiver aerial and corresponding currents will flow in the tuning circuits of the receiver.

The action of the transmitter upon the receiver can best be explained by citing a particular case. Assume a transmitter at the sending station of the 500 cycle synchronous spark type, giving 1,000 sparks per second. During each spark discharge one group of radiofrequent oscillations is induced in the transmitter aerial and each group consists of from 25 to 100 complete cycles of current varying in number as the decrement of the aerial circuit. If the receiver aerial is adjusted to electrical resonance with the oscillations of the transmitter, 1,000 groups of radiofrequent oscillations will be induced therein per second and the diaphragm of the receiving telephone will give forth a single sound for each group. The tone of the transmitter spark is therefore faithfully reproduced at the receiving station.

The actual number of groups of oscillations radiated for a dot or a dash in the International code can be fairly well calculated. Assume that a dot requires 1/15 of a second, then it will be composed of 1/15 x 1,000 or 60 + sparks. In other words, sixty groups of oscillations. Assume that a dash requires 4/15 of a second. Then each dash will consist of $4/15 \times 1{,}000$ or approximately 250 sparks or 250 groups of oscillations. No matter how many oscillations a single spark comprises, the effect at the receiving station with the simple rectifying detectors is the production of a single sound from the telephone for each group. (A detailed explanation of the working of oscillation detectors and receiving circuits will be given further on.)

SPECIAL REMARKS

(1) It is important that the student know the values of inductance, capacity, voltage, frequency, power, etc., of a simple low power transmitter of the type used aboard ships.

(2) Take, for example, the Marconi 2 K. W. 500-cycle panel transmitter; the following data cover the principal measurements:

Motor Generator	Motor—4.2 H.P.; 110 volts; speed 2,000 R.P.M. Generator—output 2 K.W.; voltage 380-110; frequency 500 cycles.
Transformer	Primary—voltage, 308-110. Secondary—voltage, 14,500.
High Voltage Condenser	Capacity—total, .012 microfarad Capacity—600 meter wave—6 jars in parallel (.012 microfarad). Capacity—450 meter wave—6 jars in parallel (.012 microfarad). Capacity—300 meter wave—3 jars in parallel (.006 microfarad).
Spark Dischargers	Quenched—15 plates; about 9 gaps actually used, depending upon power required. Rotary—30 sparking points. Spark frequency—either gap properly adjusted—1,000 sparks.
Oscillation Transformer	Type—spiral pancake. Maximum inductance—primary, about 10,000 centimeters (10 microhenries). Maximum inductance—secondary, 30,000 centimeters (30 microhenries).
Aerial Tuning Inductance	Type—spiral pancake { One, continuously variable. Other, plug type of inductance.
Short Wave Condenser	4 Leyden jars—.002 microfarad capacity; connected in series. Total Capacity—.0005 microfarad.
Aerial Ammeter	Thermo type—range 0-20 amperes.
Aerial	2, 4, 6, or 8 wires in parallel. Each wire consisting of 7 strands of No. 19 silicon bronze. Inductance—fair average, 70,000 centimeters (70 microhenries). Capacity—fair average, .001 microfarad.

QUES.—In order to place a transmitting set of the foregoing type into working order, what adjustments must be undertaken? Give them in the order of their importance.

ANS.—(1) First start the motor generator by pulling over the handle of starting box. Regulate speed carefully by means of the motor field rheostat until the frequency of the alternator slightly exceeds 500 cycles. Then close the telegraph key.

(2) Cut in and out gaps at the quenched gap until the primary wattmeter shows normal power reading.

(3) Listen in on telephone connected to a wavemeter in inductive relation to the radio frequency circuits and adjust generator voltage until the spark note is fairly clear and does not fluctuate.

(4) Place secondary winding of the oscillation transformer in fairly close inductive relation to primary winding.

(5) Select five or six turns of the secondary inductance.

(6) Close key and note reading of the aerial ammeter.

(7) Vary inductance of the aerial tuning inductance until the ammeter gives a maximum reading.

(8) Vary the coupling of the oscillation transformer until maximum antenna current is secured.

(9) Then readjust the spark note by the generator field rheostat.

(10) Do not exceed normal power input. If a clear note cannot be secured except with excessive primary power, cut out one or two gaps and readjust voltage of the generator until the note is clear.

QUES.—What precaution must be taken by the operator in the adjustment of a transmitting set?

ANS.—No part of the high voltage radio frequency circuits should be touched by the operator while the spark is dicharging; a dangerous shock may result. Also, particular care must be taken that no part of the low voltage circuits are close enough to the high voltage radio frequency circuits to permit the high voltage current to discharge directly into them.

QUES.—How, without a head telephone or receiving set, can the spark note of a quenched gap be adjusted for the best pitch?

ANS.—Correct adjustment can be obtained by listening to the note of the brush discharge from the condenser which generally can be heard several feet from the set in a quiet room.

QUES.—Under what conditions is it necessary to insert the short wave condenser in series with the aerial circuit?

ANS.—The short wave condenser must be employed with the average ship's aerial to secure the wave length of 300 meters. In general, the natural wave length of a ship's aerial exceeds 300 meters.

QUES.—What is the function of the safety gap in the foregoing diagram?

ANS.—To protect the secondary winding of the high voltage transformer and the Leyden jars from puncture in event that too many gaps are cut in at the quenched gap.

QUES.—What is the function of the reactance regulator?

ANS.—The reactance regulator may be employed to place the low voltage primary circuit in resonance with the high voltage secondary circuit, but it is generally employed to reduce the primary power. For example, in Marconi 2 K.W. 500 cycle sets, when the condenser capacity is reduced from .012 to .006 microfarad, the primary reactance regulator must be cut in the circuit to prevent arcing at the spark gap, i.e., to prevent overloading the gap.

QUES.—Suppose that when the secondary winding of the oscillation transformer is placed in inductive relation to the primary winding, no reading of the aerial ammeter is obtained, what is the probable cause of this trouble?

ANS.—It may be due to lack of electrical resonance between the open and closed circuits, the ammeter may be at fault, or there may be a complete open circuit.

QUES.—How can a commercial operator determine when the frequency adjustment of the alternator is correct, for instance, at 500 cycles?

ANS.—The frequency of the alternator can be determined by a direct reading frequency meter or by measurement of the speed of the armature per second by means of a speed indicator. For example, if the armature by this measurement revolves at 2,400 revolutions per minute, or 40 per second, and the generator has 30 field poles, then the frequency $=40\times\frac{30}{2}=600$ cycles per second. Since the speed of the generator generally decreases slightly when the telegraph key is closed, it is customary to adjust the frequency of the alternator to approximately 550 cycles.

QUES.—What are the standard wave lengths employed aboard ship in commercial practice?

ANS.—Recent types of transmitting apparatus are designed to radiate waves 300, 450 and 600 meters in length.

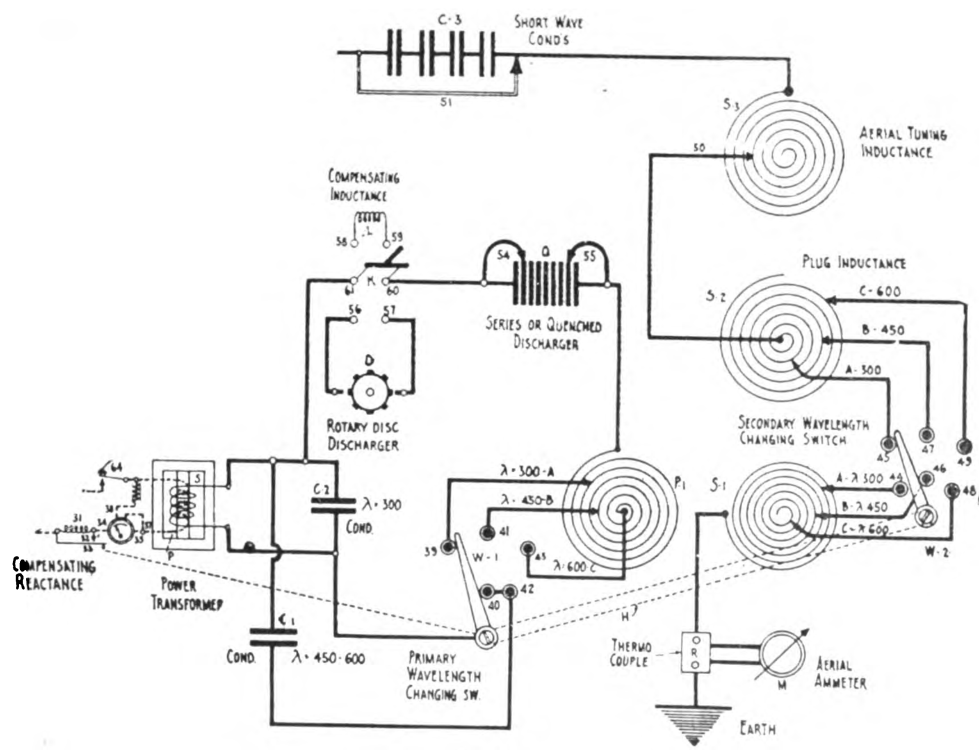


Figure 92

OBJECT OF THE DIAGRAM

To show the functioning of the wave length changing switch supplied with modern wireless transmitters.

PRINCIPLE

The length of the wave radiated by a wireless transmitter is generally changed within the station by means of variable inductances or variable condensers. By providing a special multi-point switch built in proximity to the radio frequency circuits, the required changes of inductance and capacity can be effected instantly.

DESCRIPTION OF THE DRAWING

In figure 92, the **closed oscillation circuit** of the transmitter includes condensers C-1 and C-2, C-2 being used for the 300 meter wave, and C-1 and C-2 in parallel for the 600 meter wave; also, the primary winding of the oscillation transformer P-1, the synchronous rotary spark discharger D, the quenched spark discharger Q, and the spark gap change-over switch K.

The **open or radiating circuit** includes the aerial tuning inductances S-3 and S-2, the former being **continuously variable**, and the latter **variable in steps** by flexible plug contacts; also, the secondary winding S-1, the aerial ammeter M, with the thermo couple R.

The **wave length changing switch** for the primary circuit is indicated at W-1, and for the secondary circuit at W-2. The blades of these switches operate conjointly, and by a mechanical attachment, contacts 32 and 33 which shunt a low frequency reactance coil 31, are opened and closed. When the switch is thrown to the 600 meter wave position reactance coil 31 is cut out of the primary circuit but for the 300 meter wave it is connected in the circuit, to reduce the secondary voltage. The secondary wave length changing switch, W-2, selects the proper values of inductance for the three standard wave lengths of 300, 450, and 600 meters.

OPERATION

To change from one wave length to the other, the transmitting operator throws the handle attached to W-1 and W-2 (not shown) to the wave length desired as shown by the indicator.

To place the rotary spark gap in commission, switch K is thrown downward to make contact with 56 and 57. The quenched spark gap Q is shunted out of the circuit by connecting together flexible contacts 54 and 55.

For use of the quenched discharger, switch K is thrown to contacts 58 and 59. The required number of gaps are cut in the circuit by means of flexible leads 54 and 55.

When switch blade W-1 makes contact with 39, switch blade W-2 simultaneously closes the circuit between 44 and 45. Then, if the jumper around short wave condenser C-3 is removed, the transmitter is connected **to radiate the 300 meter wave.**

For the **450 meter wave,** switch blades W-1 makes contact with points 40 and 41, which not only puts additional inductance in the primary coil P-1, but also connects condensers C-1 and C-2 in parallel. Simultaneously, contacts 32 and 33 shunting the compensating reactance 31 are closed, the set now operating at full power. At the same time contacts 46 and 47 are connected together.

For the 600 meter wave, the primary circuit is completed through 42 and 43, and the secondary circuit through 48 and 49.

The continuously variable inductance S-3 is generally set to include about 3½ or 4 turns for all three standard wave lengths, the additional inductance required for resonance being cut in at L-2. This permits the transmitting operator to compensate for slight losses of energy occasioned by the sagging of the wires (which de-tune the circuit).

SPECIAL REMARKS

(1) The closed oscillation circuit of a transmitter of this type is pre-calibrated by the manufacturer. The connections A, B, and C on the primary inductance are soldered in position permanently.

(2) A small compensating inductance, L, mounted between points 58 and 59 maintains the frequency of the closed circuit constant. The connections to the rotary and quenched gap are of unequal length. Hence, without this inductance, the taps on the primary coil would have to be changed for either gap.

QUES.—How is the apparatus shown in Figure 92 tuned to the standard wave lengths?

ANS.—By selecting the correct values of inductance in the secondary circuits so that by merely shifting the position of the switch blades, maximum antenna current is assured at all wave lengths.

QUES.—What is the relation of the primary and secondary coils in these sets?

ANS.—They remain in a fixed position, being separated no more than two or three inches. Provision is made whereby the coupling can be shifted mechanically during the tuning process, but when completed, the coils remain in a fixed position. The proper coupling for the maximum aerial current is secured by changing the self inductance of the secondary winding.

QUES.—Explain more in detail how the set is tuned?

ANS.—The process is more or less a cut and try method, but from the experience gained by tuning a few sets, the inspector can find the proper positions for the plug contacts of the antenna coils with little difficulty. Since the primary circuit is calibrated to standard wave lengths, a wave meter is not essential for tuning.

The first point to be considered is that we must obtain the maximum antenna current for each wave length. This only can be accomplished by tuning the primary and secondary circuits to resonance and by adjusting the coupling of the oscillation transformer until the aerial ammeter M indicates the maximum reading. Now, if the coupling of P-1 and S-1 had to be changed mechanically for each new wave length, another operation to the throwing of the wave length changing switch would be required. To avoid this, the best coupling for each wave length is found by cutting out turns at the inductance S-1 and inserting a similar amount of inductance at coil S-2 or S-3 until resonance is established.

The correct location of the inductance taps can be facilitated by changing the coupling mechanically to ascertain whether turns must be added or subtracted in the secondary.

QUES.—Explain more in detail how the positions of the taps on the antenna coil are found for a given wave length.

ANS.—The process is as follows: Assume that the set is to be tuned to 600 meters. (1) Throw the wave length changing switch to the 600 meter position which insures, owing to the pre-calibration of the circuit, that the frequency of the primary oscillations corresponds to this wave length. (2) Then place the secondary winding S-1 in inductive relation to the primary winding. (3) Insert a few turns of this coil at point C. (4) Similarly insert two or three turns in the coil S-3 through the plug contact connected to point 49. (5) Turn the handle on the aerial tuning inductance S-1 either to the right or to the left until the ammeter indicates a maximum.

If the reading of the ammeter is maximum with all of the turns of inductance, S-3, cut in or cut out, exact resonance has not been established. In the former case, cut out turns at S-2 or S-1. In the latter case, do the reverse, i.e., add turns at S-1 or S-2. Then find such values at S-1 and S-2 that the maximum antenna current is secured with approximately three or three-and-a-half turns cut in at S-3.

Resonance is now established, but the operator is not assured that the maximum antenna current is secured.

QUES.—How can this be determined?

ANS.—By change of the coupling, i.e., by placing winding P-1 closer to or drawing it away from the secondary winding S-1. If placing winding S-1 closer to P-1 increases the antenna current, it indicates that the coupling previously adopted is not close enough for maximum antenna current. Hence, P-1 is drawn back to its normal position, (with separation of 2 or 3 inches) turns being added at S-1 and a corresponding reduction being made at S-2 until the reading of the ammeter becomes maximum.

QUES.—Should full power be used while the set is being tuned?

ANS.—In a 2 kw. set, for example, no more than 1 kw. should be drawn; since the antenna circuit is not in tune with the closed circuit an excess of current flows in the closed circuit which may over-heat the spark gap. After the correct values of inductance and capacity for the open and closed circuits are secured, the set should then be operated at normal power in order to ascertain if normal value of antenna current has been secured.

QUES.—Approximately what antenna current can be obtained with transmitters of various power?

ANS.—The value varies widely with the power of the transmitter and the constants of the antenna circuit. The average values to be expected from Marconi marine type of transmitters at the wave length of 600 meters follow:

	Antenna Current (Average)		
Power Rating	600 met.	450 met.	300 met.
2 kw. 500 cycle	12 to 17 amp.	9-13	3 to 5
½ kw. 500 cycle	5½ to 8	5-7	2 to 4½
½ kw. 120 cycle	5 to 7		1½ to 3
1 kw. 60 cycle	5 to 7		1½ to 3
2 kw. 240 cycle	5½ to 8		1½ to 3
¼ kw. 500 cycle	3 to 4		1 to 2

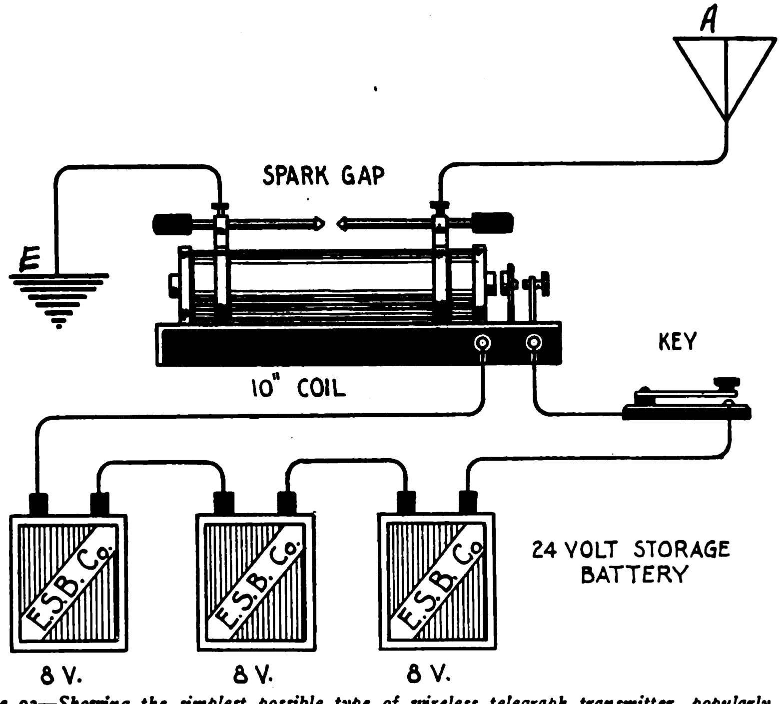


Figure 93—Showing the simplest possible type of wireless telegraph transmitter, popularly known as the "plain aerial" set. An induction coil giving secondary voltages without shunt capacity up to 100,000 volts is connected to a simple spark gap as shown. One electrode of the gap is connected to the earth and the other to the aerial wires. A storage battery of the capacity of 60 to 80 ampere hours and E.M.F. from 16 to 30 volts energizes the primary circuit through a magnetic interrupter mounted at the right-hand end of the base.

When the key is closed, the aerial is intermittently charged to a high potential and a succession of sparks discharge across the gap. Each spark consists of a few cycles of radio-frequency oscillations, the frequency being determined by the distributed inductance and capacity of the aerial, and the resistance of the spark gap. Each group of radio-frequency oscillations radiates a train of electromagnetic waves. If such an oscillator has no localised inductance at the base, the antenna oscillations are rapidly damped out resulting in the radiation of what is termed a "broad" wave. A few turns of localised inductance inserted at the base, however, reduces the damping to a value conforming with Government regulations.

(To be continued.)

MILITARY SIGNAL CODES

A Few Timely Observations on Army Practice With Recommendations for Consolidation and Simplification

By LIEUT.-COL. B. O. LENOIR, Signal Corps, U. S. Army

WHEN a man enlists in the Signal Corps, he is confronted with learning all the duties of a soldier—the drill, care of horses, and numerous other duties, and of course the profession of the signalist.

In civil life it requires several years to acquire the skill of the expert telegrapher, even when the mastery is the sole object to be attained. Natural talent is also required, for if it is lacking expertness will never be attained, i.e., the art of sending and receiving 30 to 45 words per minute without thinking about it, and turning out perfect copy without corrections. He who thinks is not an expert. There is no time for thought; fast telegraphing must be done after practice so long and constant that operation is entirely by intuition.

But in the Signal Corps, in addition to numerous duties, the recruit must learn four signal codes, or languages, i.e., the American Morse Code, the International Morse code, the General Service code, and the Semaphore code—quite a Herculean task if it is done properly. It is no wonder that civilian experts who carry on the signal business of 100,000,000 people and the press news of the country balk at the idea of being reduced to recruits in three additional signal languages!

Expertness exists in civil life because there is much practice and a concentration on a single code; similar tactics in the Army will be attended by similar results.

The common law signal language in the United States and Canada is the American Morse code, used by one-quarter million of the most expert signalists on earth, and there seems to be no reason why this common law signal language should not be adopted in the Army for all signaling. Advantage could then be taken of the expert talent that exists in the United States. This code should be an invariable standard for all signalists to follow; for every class of signaling can be done with the American Morse code. There is no reason to depart from it and lose the advantage of the best precedent, besides risking confusion by adopting something different.

Objections have been advanced as to why this can not be done. It is claimed that owing to the spaced letters it cannot be used in the Wig Wag or in the Ardois signal system.

As to the Wig Wag, nothing is more simple than to overcome this objection. In the early nineties, an attempt was made to adopt this code for all purposes. After several years practice it was abandoned on account of the mistake which was made in its adoption, i.e., the space in the spaced letters was shown by a motion to the front with the flag, being the same as at the end of a word; and in addition it was a motion hard to distinguish, owing to

the fact that it was made by showing the edge of the flag to the observer.

The original adoption of this code itself showed the remedy; and had it been applied we would now be enjoying the consolidation and simplification which is so much desired. The remedy was this: The letter T was made with a quick motion to the left, which was a short dash, and the letter L was made by a motion to the left, pausing at the lowest point of the flag, which in fact made the long dash for L as it should be.

By applying this principle to the right, the objection of the spaced letters is entirely overcome. There are five spaced letters and the following shows how easily they can be signaled in a manner to show plainly the spaces in the spaced letters:

C, right, right pausing at lowest point of flag, right; equal to .. .
O, right pausing at lowest point of the flag, right; equal to . .
R, right pausing at lowest point of flag, right, right; equal to . ..
Y, right, right pausing at lowest point of flag, right, right; equal to .. ..
Z, right, right, right pausing lowest point of flag, right; equal to ... .

During the six years of adopting, the pause between T and L was very plain, and a mistake on this account was never made. There is every reason to believe the same success will be reached by applying the pause to the right to indicate the space, which space it is in fact, and is actually made by the pause.

The American Morse code can also be applied to the Ardois system of signals in a perfect manner by adding one more red light to the four red lights now in use, making five red lights and four white lights, or a total of nine lights as against eight lights now in use: The red lights would be arranged as follows in the Ardois system to show the spaced letters:

Total red lights	*C*	*O*	*R*	*Y*	*Z*
•	•	•	•	•	•
•	•			•	•
•					•
•			•	•	
•	•	•	•	•	•

It will be observed that the spaces in the spaced letters are actually shown; nothing could be plainer.

There appears no necessity in the Army to learn a foreign signal language to take the place of our American common law Morse signal language.

It has been thought by many that visual signaling, as it is so little used, requires little attention. The very fact that it is little used demands extraordinary attention.

A code much used, as is the American Morse code, requires no extra attention, as its constant use automatically makes efficiency a matter of course. But with a plurality of codes, the less each code can be used; confusion results and more care and attention are required. The efficiency of all

kinds of signaling with those who have a gift for the art, is directly proportional to the amount of use given to it; while those with no talent, or with little practice, will never make efficient signalists, for neither will ever learn to read by intuition; nor will those with cares on their minds learn this degree of expertness; it must be learned before cares and responsibilities accrue. Once learned intuitively, however, it is never forgotten.

For the reason that no officer is free from cares and responsibilities, an officer, unless he is an expert before he obtains his commission, cannot be expected to be an expert signalist such as we find among professional signalists. By no means should an officer consider himself as a standard for others to follow in signaling, but he can use his rank and influence in holding men to the work when he studies the necessities that are required.

To be an expert telegrapher requires four or five years of constant and laborious practice; even with natural talent, as much time and talent are required as to pass through any college in the country, or to learn any of the other professions. Signaling must be done constantly to create intuition; there is no time to think or reason; he who has to think or reason is inexpert in the art. For these reasons it is dangerous to depart from the practice of the art as developed since the days of Professor Morse. The constant use of his code has developed a degree of efficiency, that cannot even be imagined by those who are not his ardent disciples. Some of the brightest minds in the country have passed through his school of practice, and his graduates are numbered among all the arts and sciences, professions and business. Some of the largest railroad systems in the counrty are run by them, and other large businesses are operated by those who have served as disciples of Morse. For this reason little attention should be given to the constant demand for changes from those new in the art, who seek a short cut to make efficient signalists; until a man has actually become an expert he should not be heard on the subject of changes.

The ideal signal language for the Army would be the American Morse code; it is as permanent as the English language, and should be no more changed than the English language. The American Morse code should be used in every branch of signaling; it should be the basic signal language, and the exception should be the use of the *European Morse code for communication with the Navy, which is only infrequently required, but this can be automatically provided for by paying the masters of the European code one dollar per month for this mastery—that is, when they are accomplished in both codes.

This arrangement will put the signal system of the Army on a rational basis, and in unison with the grand signal system of our country, instead of creating the European code as our standard. It will bring the Army to the people, or the people to the Army, whichever way one desires to look at it.

Now the question naturally arises, "What will be done with the Semaphore Code?"

The alleged use of this code is to provide for rapid short distance signals. After several years daily practice by 200 men under my command, and a close system of testing and timing, I will say that good readable signals can be made by experts at fifteen words per minute in wig wag and semaphore both. Occasionally, men can reach between twenty and twenty-five words per minute in both codes, but reliable visual signaling cannot be reached beyond, say, fifteen words per minute. At any greater speed there is danger of slur-

*Continental.

ring the signals and running them together; the result is unreliable, especially where hard words, or uncommon words, or code words are used.

Practically the same result can be obtained with the American Morse code, by getting away from an old habit, i.e., considering the two foot flag as the smallest flag that can be used.

Just adjust the Wig Wag medium to the distance: for long distance a large medium; for short distance a small medium. Remember that the longer the distance, the larger the medium and slower the motion must necessarily be; and the shorter the distance the smaller the medium that can be used and the more rapidly the signals can be made.

Long distance Wig Wag is expertness only for the eyesight. Although it impresses the casual observer, for signal efficiency it is a poor standard, as the signals are necessarily slow. For real Wig Wag signal efficiency, use a small medium at a short distance, using only one hand and a combination of the arm motion and the telegraphers wrist motion. He who can read these rapid short distance signals can read signals at any distance that he can see, for the greater the distance the greater the medium used, and necessarily the signals must be slower. Short distance wig wag signals thus made can be made by exceptional men up to twenty-five words per minute.

Applying these principles with 200 men for several years, using a thin, very light disk, of practically no weight, and about twenty inches long, it is found that the Wig Wag is practically as fast as the semaphore, and the necessity for learning a separate language only for rapid short distance signals vanishes, and thus paves the way for one code, i.e, the American Morse code, to be adopted as the basic signal language of America. Thus will the burden of signaling be very materially reduced, and the barrier of four signal languages that at present faces and discourages the signal student, will in a measure disappear. By centering on one code greater efficiency can be expected, and this expectation will most assuredly be realized.

By cultivating rapid short distance with the Wig Wag instead of the semaphore, using a small light medium that can easily and rapidly be operated with one hand, interest in the Army will at the same time also be created in telegraphy, by cultivating an interest in the American Morse code and prepare the learners for further advancement, not only in telegraphy, but indirectly for the radio as before outlined, by giving a small increased monthly compensation.

As Navy signaling has some slight connection with Army signaling, these same principles could be applied in the Navy, the semaphore abolished there, and the European Morse code used in the Navy for rapid short distance signals, and interest in the Navy Radio created direct, thus reducing the telegraphic code in the Navy to one code; while in the Army the European code should be the exception, and learned as previously outlined, the American Morse code being the basic signal language. In neither service does the Semaphore appear essential, but is, on the contrary, confusing.

Thus in the Army it is seen that two signal languages* are necessary, while in the Navy only one is necessary. It should be remembered that in both services the same rapid short distance Wig Wag signals can be used for long distances, by simply increasing the size of the signal medium used.

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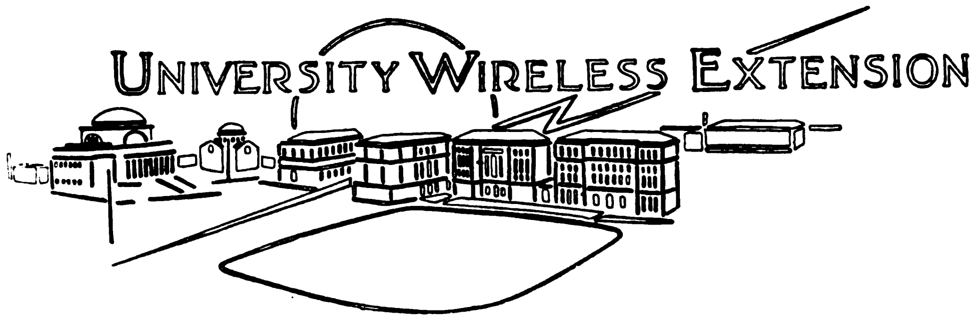
*American and European Morse only, abolishing the semaphore.



Radio Telephony

By **ALFRED N. GOLDSMITH, PH.D.**

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE XIV

(i) **COMPARISON OF CONTROL SYSTEMS.** The choice of modulation control system will depend markedly on the output of the radiophone transmitter and, to a less degree, on the type of installation, i. e., ship or shore station, fixed or portable outfit.

For low-power sets, the placing of the microphone directly into the antenna (as illustrated in Figure 13) is a simple solution and one that is economical of apparatus. It is not, however, economical of energy since the microphone resistance for most efficient operation must be equal to that of the remainder of the radiating system. This condition necessarily involves the loss of half of the available radio frequency energy in the microphone. To some extent this loss may be avoided by the use of one of the circuits shown in Figure 119, whereby the microphone is more fully utilised in that the changes in its resistance vary a number of the electrical constants of the associated circuits and thus produce greater proportionate changes in the antenna current.

For moderate power sets, the difficulties in getting a suitable control system become quite serious. Large numbers of microphones in parallel are bulky and expensive, and tend to cause difficulty in adjustment. Heavy current microphones seldom give the highest quality of articulation and liquid microphones are not easy to build or to shield from disturbance. On shipboard their use is even less desirable than on land. It becomes necessary to use some type of control based on one-way amplifiers (such as the methods of the General Electric Company involving absorption in pliotrons as shown in Figures 163 and 164, and a number of allied methods) or else to use ferromagnetic amplifiers. These last should be so constructed that they are one-way devices so far as possible, in order that there shall be no induction of radio frequency currents in the control or microphone circuit.

For high power sets, direct microphone control is, of course, out of the question. Even the use of the normal vacuum tube amplifier in any of its modifications or modes of use seems of doubtful utility unless some very heavy output bulbs should be constructed in the future. The most feasible methods at present seem to be those involving the control of the outgoing energy by rugged ferromagnetic amplifiers. The control energy for these amplifiers may itself be obtained by the use of vacuum tube or of smaller ferromagnetic amplifiers. In other words, a composite system depending on the use of a rugged final amplifier is desired, its control energy being derived from a more delicate amplifier which can be actuated by the small amount of microphone energy actually available.

It may be here mentioned that the difficulties of the situation are considerably increased when it is desired to control the radiophone transmitter from an ordinary wire telephone line. The power available from an ordinary telephone line is of the order of microwatts. whereas the power derived directly from the transmitter may be 100 or 1,000 times as much. The difference must be made up in the former case by at least one audio frequency amplification.

8. ANTENNAS AND GROUND CONNECTIONS.

(a) RADIATING SYSTEMS. For transmission in radio telegraphy, much the same requirements must be met as in the case of a normal sustained wave telegraph station. That is, a high capacity antenna of low ohmic resistance

	WAVE LENGTH		
	1,600 m.	3,200 m.	6,400 m.
Ohmic Resistance of Antenna...	0.3	0.2	0.1
Ground Resistance............	1.0	2.0	4.0
Radiation Resistance	1.0	0.25	0.06
Loading Coil Resistance........	0.3	1.2	4.8
Total Resistance...............	2.6	3.65	8.96
Antenna Current...............	19.6	16.6	10.6
Radiated Power (watts)........	385.	69.	7.
Radiation Efficiency (in per cent.)	39.	6.9	0.7

is desired. The radiation resistance should be the chief portion of the total antenna resistance else the efficiency of radiation may be very low. This can be well illustrated by the following numerical example:

Suppose an antenna to have an effective height of 40 meters (130 feet), and that 1 kilowatt is available for the antenna circuit. Suppose further that the antenna is used successively at wave-lengths of 1,600, 3,200, and 6,400 meters. In the table below are given values of the probable ohmic resistance of the antenna, its ground resistance, and its radiation resistance at each of the wave-lengths. These are calculated on the basis that the ohmic resistance increases as the frequency increases (i. e., as the wave-length diminishes), that the ground resistance diminishes almost inversely proportionately to the wave-

length, and that the radiation resistance is inversely proportional to the *square* of the wave-length. The antenna current is then calculated from the total resistance, and the radiated energy and radiation efficiency in per cent. The resistance of antenna loading coils is omitted for simplicity; and this omission does not affect the nature of the results.

It is clear enough, everything else remaining the same, that the shortest wave-length (nearest to the antenna fundamental) would be by far the most suitable so far as radiation efficiency is concerned. However, the absorption of the electromagnetic waves in passing over the intervening country may partially or entirely nullify this difference, and thus it may occur that by day and for overland transmission the best wave would not be the 1,600 meter wave but possibly the 3,200 meter wave. For the case mentioned, with the relatively small antenna power available, the transmission could hardly be over a great enough distance to make the longest wave given the most desirable. In other words, in every case of day transmission, there will be some wave-length for which best results are obtained because a diminution of wave-length below this most favorable value, while it would increase the radiation efficiency, would more than correspondingly diminish the freedom from absorption in the intervening space.

In constructing antennas for radio telephony, all the usual precautions as to antenna insulation, ground resistance, freedom from neighboring energy-absorbing conductors and guy wires are observed. In addition, it should be remembered that it will be sometimes necessary to use a suitable coupling between the antenna and the radio frequency generator in order that the resistance which is thus, in effect, introduced into the generator circuit shall have the most favorable value for full generator output.

A "fly-wheel effect" similar to the "inertia effect" mentioned under "Causes of Distortion in Radio Telephony" may occur in the antenna circuit. If the persistency of the antenna system is very great, i. e., if the damping is very small, the wave trains in the antenna will tend to persist at full intensity and the difficulty in getting complete modulation may become excessive. As regards this feature, which is most prominent at long waves, there is a conflict between good antenna design in the usually accepted sense as indicated above, and the design indicated to avoid the fly-wheel effect. In general, however, the compromise will be satisfactory if the fly-wheel effect is practically disregarded, except for long waves and very persistent antennas.

(b) **RECEIVING SYSTEMS.** The same general considerations as hold for transmitting antennas also hold for receiving antennas except that smaller antennas will in general be used. This is because of the diminished expense, because of the large static charges which readily accumulate on large antennas, and because it is easy enough to amplify the signals received on a small antenna to satisfactory values. Of course, the fly-wheel effect mentioned previously may again occur in the tuning of sharply resonant radio frequency circuits, though the Author has not experienced much trouble on that score using waves of moderate length. The present tendency seems toward the use of small antennas with sensitive receiving sets and high amplification of some sort. It

seems that the ratio of signal strength to stray intensity remains reasonably constant as the size of the antenna is diminished, at least when crystal detectors or detectors of the audion type are used. For the oscillating audion, Mr. Armstrong has pointed out that this is not necessarily the case, since the oscillating audion favors weak signals compared to heavy strays to a greater extent than does the plain audion. So that, unless the beat method is used for reception, radio telephonic reception may just as well be carried on on small antennas as on large.

9. RECEPTION PHENOMENA.

(a) DETECTOR AND AMPLIFIER TYPES. Almost all detectors have been used for radio telephony, and indeed all but the coherer type can be used. At the present time such detectors as the crystal rectifier, the audion, and the dynatron have proven to be practically usable and satisfactory. The detectors and amplifiers used in radio telephony should have a linear characteristic like that mentioned in connection with Figure 6. Otherwise there will be speech distortion of the types described in the discussion to which reference has been made. Both detectors and emplifiers should be of such sort that they are easily adjusted to maximum sensitiveness, retain this sensitiveness indefinitely, do not require frequent renewal, and are inexpensive. These requirements have not yet been entirely met.

(b) BEAT RECEPTION. Beat reception is possible in radio telephony, and there may be used for this purpose either the normal detector with an external oscillator circuit coupled to the receiving system to produce the beats or the so-called "self-excited heterodyne" where the same vacuum tube is used at once as an oscillator, detector, and amplifier. Generally speaking, this latter arrangement, while convenient in manipulation and economical of equipment, does not utilise to the full the various properties of the bulb and is less stable and certain of adjustment than the former.

It need hardly be said that for beat reception in radio telephony extreme constancy of frequency at the transmitting end is essential. This will be evident when it is considered that radiophone reception under these conditions requires either zero beats per second (that is, equality of frequency of the transmitter and of the local oscillator at the receiver) or a beat frequency above audibility (that is, a greater difference between the transmitter frequency and the local oscillator frequency than say 10,000 cycles per second). As a matter of fact, only the first of these expedients is practically usable since the detuning of the antenna and its associated circuits in the receiver for the second case would make the reception very inefficient except on extremely short waves where a difference of frequency of 10,000 or more cycles per second is only a small percentage of the main transmitter frequency. However, it must be admitted that zero beat frequency is usually not very easy to obtain or hold as a receiver adjustment and even slight variations in transmitter or receiver oscillation frequency will then cause a drummy quality to appear in the speech and seriously impair its intelligibility.

With radiophone transmitters employing alternators, or alternators and frequency changers, very perfect speed regulation will therefore be required if

beat reception is to be used. For example, working at 6,000 meters wave-length (50,000 cycles per second), a much greater speed variation than one part in 10,000 would be objectionable; and if frequency multipliers were employed in conjunction with the alternator to get the 50,000 cycles per second, even greater accuracy would be necessary. When bulb radiophone transmitters are used, the filament currents and reactions on the oscillator must be kept quite constant else there will be changes in the emitted frequency even in this case, and beat reception will not be feasible.

(c) **SELECTIVITY IN RECEPTION.** There is a fairly sharp conflict between the requirement of loud signals and extreme selectivity. The first of these generally requires sensitive detectors and powerful amplifiers used with close coupling to the antenna system, while the second tends in the opposite directions. Nor does beat reception solve this problem as will be evident below. All that can be said is that a rational compromise must be effected in every case, this to be determined by the operating conditions in the neighborhood of the receiving station. Thus the amount of interference in the vicinity of the receiver is an extremely important factor in determining the amount of power required at the transmitter to cover the desired distance. This is a factor which is often overlooked in the design of stations.

There is also, particularly at long waves, a conflict between the extreme antenna persistance necessary for adequate selectivity in reception and the undesired fly-wheel effect which has been previously mentioned. This, again, must be met by compromise.

(d) **INTERFERENCE WITH RADIOPHONE RECEPTION.** Interference from spark stations disturbs radiophone reception less than might be expected, partly because the dots and dashes constitute a more or less intermittent disturbances through which portions of the words can be heard and partly because of the resulting "assistance of context" effect. Sustained wave station interference is, however, very serious since this causes a continuous musical note by the beats with the incoming radiophone frequency and this continuous musical note cannot be tuned out either by ordinary or beat reception being a physically present phenomenon caused by two frequencies *external* to the receiving station. In the neighborhood of a large arc radio telegraphic station, this may become a very grave matter particularly if compensation waves are used by the arc station in transmission. In this latter case, there will generally be produced a long series of overtones of both the sending and the compensation waves, and there is very likely to be continuous beat interference. The Author is very much of the opinion that radiation at non-useful frequencies should not be permitted since the growth of the radio art will be much hampered thereby. Furthermore, provision should be made in all sustained wave stations to avoid the production of these series of overtones, (which, it may be mentioned, are frequently not harmonics but fall at non-integral multiples of the main and useful frequency).

(e) **TELEPHONE RECEIVERS.** It might be expected that there would be no great difference between the various telephone receivers used in

radio sets, so far as speech reception were concerned, but this is far from being the case. In addition to marked differences in intrinsic sensitiveness, the receivers show differences as to the extent to which they distort speech and the relative extent to which they respond to the sudden shocks caused by heavy strays. Generally speaking, the receivers with diaphragms of moderate thickness give good articulation, moderate sensitiveness, no inordinate response or "singing" when stray impulses are received, and are robust. More sensitive receivers with very light diaphragms tend to give "tinny" speech and more than proportionate response to impulses.

A number of other types of receivers besides the usual electromagnetic type have been suggested. Thus Messrs. Fessenden, and, later, Ort and Rieger have built electrostatic receivers. These are nothing more than a condenser one or both sets of plates of which are movable. The electrostatic forces developed as the difference of potential between the plates changes will cause minute movements of the plates and consequent sound. Sometimes an auxiliary potential is kept constantly on the plates and they are under considerable tension, this being found to increase the sensitiveness greatly. Such an arrangement, though it approaches the usual receiver in sensitiveness, is not particularly convenient and has not found favor in the commercial radio field.

Mr. Fessenden has further developed and used a receiver based on alternating current repulsion between two coils of wire each carrying the same current, or a current of nearly the same frequency. The construction of the device was simple. Two flat spirals of thin wire were placed parallel and near to each other, and the incoming current passed through both, or else through one of them with a locally generated radio frequency current passing through the other. While the device was operative, it did not find favor in the radio field, and is not used in practice at present.

(f) **RECEIVING APPARATUS.** The first receiver we shall consider is that shown in Figure 187. It is the usual audion used as a detector. Incoming radio frequency energy causes radio frequency potential differences at the terminals of the secondary tuning condenser C_1. Consequently alternating current tends to flow in the grid-to-filament circuit, C_1C_2GF. However, since the grid-to-filament has unidirectional conductivity only, the grid gradually accumulates a larger and larger negative charge, which charge cannot escape through L_1 to the filament because of the grid condenser C_2. In consequence of the increasingly negative potential of the grid, the

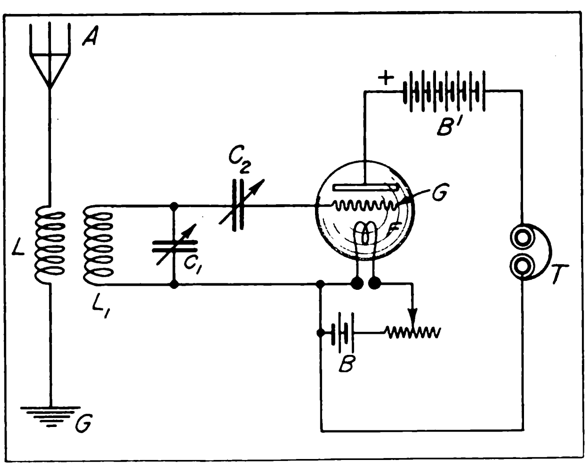


Figure 187—*Normal audion receiver*

current in the plate circuit diminishes. If the signals cease, the grid leakage (through the condenser C_2, through the glass supports of the grid, and because of any residual positive ionisation due to gas molecules in the space between the grid and filament) will speedily bring the grid potential back to normal and the plate current will then increase to its usual value. As a result of this action, variations in the incoming radio frequency currents, such as occur in radio telephony, will be approximately followed by changes in the plate current of the audion. A supplementary resistance may be shunted across the grid condenser so as to increase grid leakage and improve the fidelity of reproducton of speech in the plate circuit. This will generally diminish the audion sensitiveness. The resistance used in practice for this purpose are pencil lines, graphite rods, or liquids (e. g., xylol), and have values ranging from a few thousand ohms to several megohms.

As explained in connection with Figure 69, Mr. E. H. Armstrong has devised a number of methods of using the audion as a regenerative relay by coupling the plate and grid circuits. Such an arrangement adapted for telephonic reception and giving radio frequency amplification is represented in Figure 188. As will be seen, the grid circuit $L'C_1L_1$ is coupled to the plate circuit by means of the inductive coupling $L'L''$. Armstrong has found in bulbs used by him (high vacuum bulbs) that the regenerative amplificaton obtained was fifty-fold in energy or about 7 times in audibility (as audibility is usually defined, namely, as directly proportional to the current through the telephone receivers). It will be noted that the telephone T is shunted by the condenser C', the purpose of which is to permit the passage of the radio frequency current while forcing the audio frequency currents of the signal to pass through the receivers.

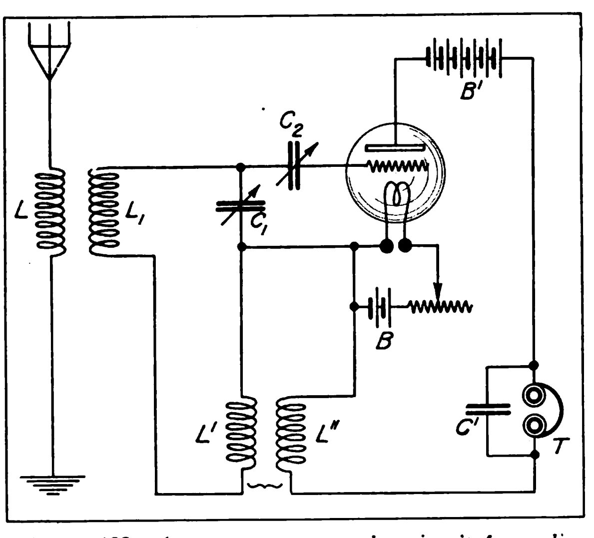


Figure 188—*Armstrong regenerative circuit for radio frequency amplification*

An improved arrangement, also due to Armstrong, is shown in Figure 189. Here, in addition to the regenerative coupling between the plate and grid circuits, we have tuning of the plate circuit by means of the inductance L_2 and the condenser C''. As before, the receivers T and the plate battery B' are shunted by the by-pass condenser C'. Another interesting modification is given in Figure 190. Here the coupling is secured by means of the large inductance L' and the capacity C_1. The details of this circuit together with the detailed explanations of the various circuits here outlined and similar circuits can be obtained in the "Proceedings of The Institute of Radio Engineers,"

for September, 1915. It need only be mentioned here that it is recommended that the inductances in the plate and grid circuits be large and the capacities small.

For the sake of completeness, we include here as Figure 191 the de Forest ultraudion circuit which has previously been explained in connection with Figure 76. The modified ultraudion circuit having grid and plate circuit coupling by means of the so-called "tickler coils" is shown and explained in connection with Figure 77.

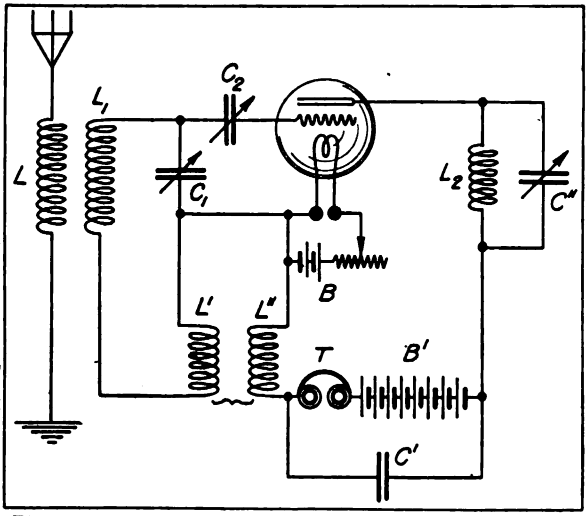


Figure 189—Armstrong regenerative circuit for radio frequency amplification with plate circuit tuning

The actual appearance of a de Forest assembled audion and ultraudion receiving set is indicated in Figure 192. The tubular audion is mounted at the left with its carbon sector potentiometer (for obtaining a continuously variable plate potential) to the right of the supporting socket. The bridging condenser and the stopping condenser (C' and C_2 respectively of Figure 191) are controlled by the switches below the bulb. The three top-row knobs control an antenna loading coil, a secondary loading coil, and a coupling between the primary (antenna) circuit and the secondary circuit. The two lower knobs control an antenna tuning condenser and the secondary circuit tuning condenser. It will be seen that a special switch is used in connection with the loading coils so as to avoid dead ends when using only a portion of each coil.

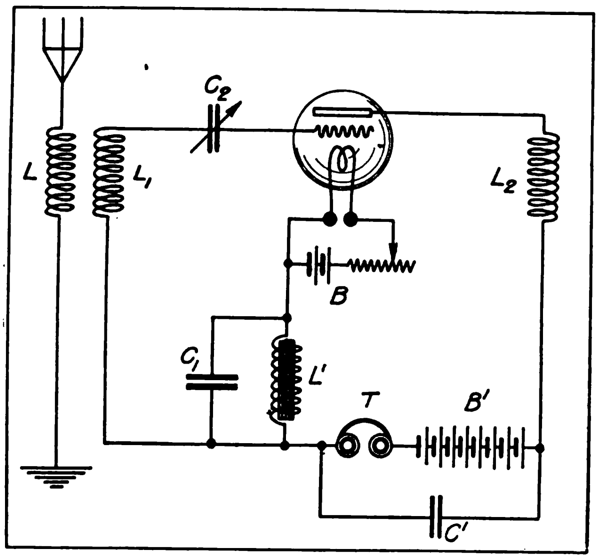


Figure 190—Armstrong regenerative circuit for radio frequency amplification

The general appearance of the de Forest audion and three stage amplifier is shown in Figure 193. The lowest bulb is the detector, the remainder are audio frequency amplifiers. Each has its own filament current rheostat and its own cell plate battery

variable in steps of 3 volts. The telephone can be plugged in at any stage as desired.

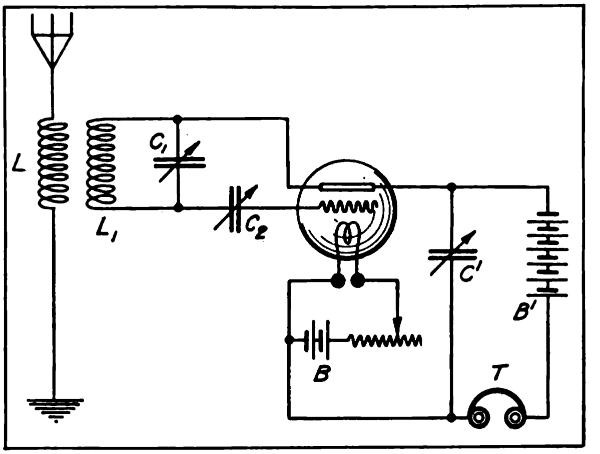


Figure 191—*de Forest ultraudion receiver*

In Figure 194 is represented a general type of circuit devised by Dr. Meissner of the Telefunken Company. It differs from the preceding in the method of obtaining plate circuit outputs. Instead of inserting the telephone receivers into the plate circuit, the large inductance L_2 is placed in this circuit, and the alternating potential differences appearing at its terminals cause currents to flow in the tuned circuit L_3C_5 which is coupled to L_2 by the condensers C_3 and C_4. The right hand bulb serves as a detector and amplifier, and finally delivers audio frequency currents to the telephone T. Another form of receiver of

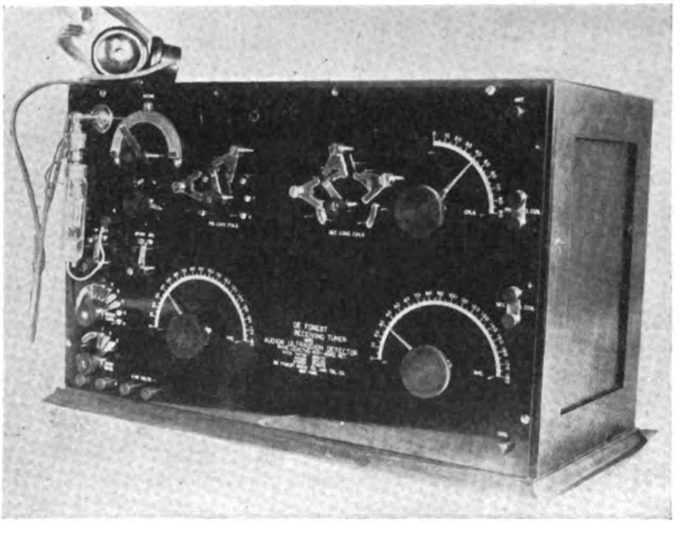


Figure 192—*de Forest Company receiver,* 1914

the Telefunken Company, devised by Count von Arco and Dr. Meissner is represented in Figure 195. It will be seen that this differs from Mr. Armstrong's circuit of Figure 189 only in the mode in which the plate circuit output is delivered to the receivers.

The receiving set used with the Marconi Company's radiophone trans-

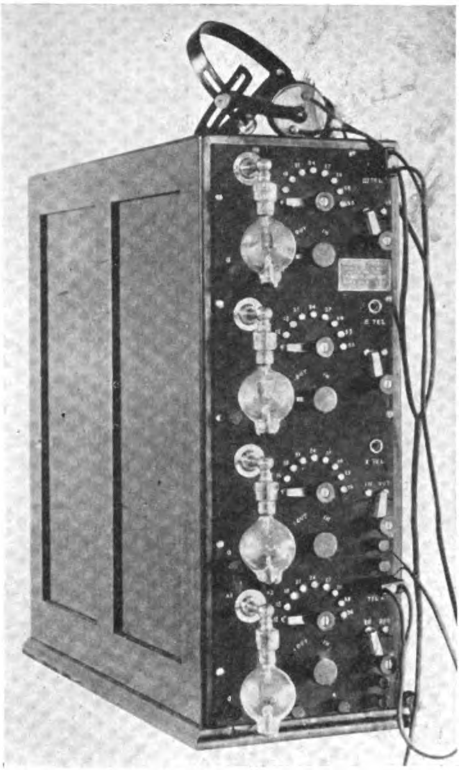


Figure 193—*de Forest audion and three stage amplifier*

mitter shown in Figure 141 and described in conjunction therewith is indicated in Figure 196. The grid circuit is coupled directly to the antenna circuit through a portion of the antenna inductance L and the inductance L'. The grid circuit is also coupled regeneratively to the plate circuit through the coupling between L' and L''. The plate circuit is tuned by means of the condenser C'. The plate battery B has a voltage of 200 and the resistances R_1 and R_2, which limit the plate current, are each 2,000 ohms. The battery and its associated resistances are shunted by the condenser C'' which passes the amplified radio frequency current. The filament of the bulb is lit by the 6 volt battery B', and grounded through the potentiometer resistance R'. The output of the plate circuit is drawn from the condenser C' across which is placed the usual crystal detector, auxiliary potential, and telephone receiver combination. In other words, the system shown consists of a regenerative radio frequency amplifier combined with an ordinary crystal rectifying circuit for utilising the amplifier output.

Passing to the work of the Western Electric Company, we consider first some

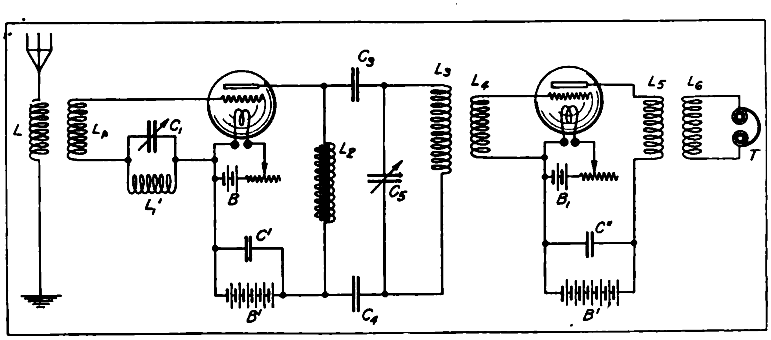


Figure 194—*Telefunken Company-Meissner receiving system*

of the tubes developed by the engineers of that company and their method of construction. One type of tube, due to Mr. H. J. van der Bijl, is shown in Figure 197. Herein the objects are to keep the planes of the grid and

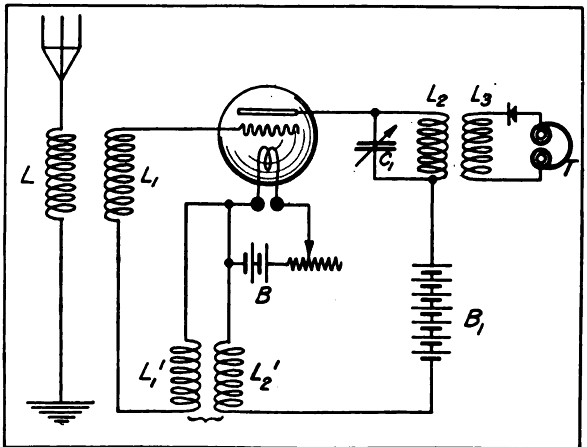


Figure 195—Telefunken Company-Arco-and-Meissner receiving system

filament close together (for high amplification) and to avoid undue tensions on the filament. As will be seen from the lower portion of the Figure, the filament is threaded to and fro on the flat mica support, passing alternately from one side of the mica to the other. The grid and its supporting frame are mounted close to the mica, and are preferably arranged as shown in the lower portion of the Figure,

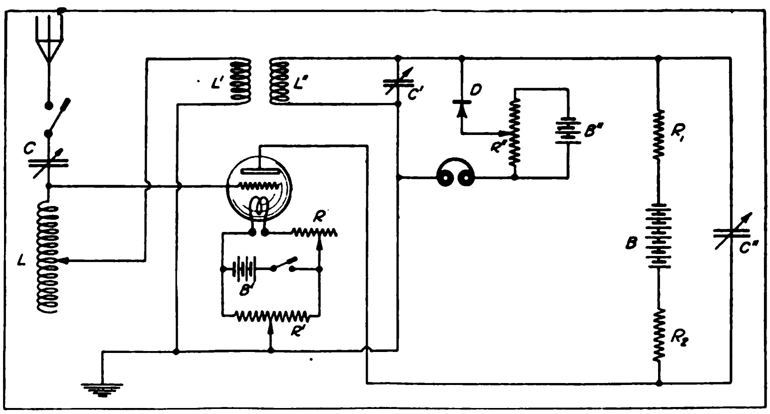


Figure 196—Marconi Company radiophone receiver

that is, with grid wires not crossing at the portions of the mica where the small vertical portions of the filament are exposed on that side. In another form of tube, due to Mr. A. McL. Nicolson, and represented in Figure 198, it is attempted to secure "efficient control" by twining the grid wire around the filament, separating them only by a non-conducting or dielectric film. Nickelous oxid is recommended for the purpose. In the form shown in Figure 198, the grid wires 1 are coated with nickelous oxid, and around them are twined the filament wires 2. The plates 3 are situated as usual.

A type of Western Electric Company amplifier or "repeater" tube is shown in Figure 199. This type is due to Messrs. A. McL. Nicolson and E. C. Hull. The distinctive feature thereof is the twisted platinum filament 2, which is coated with metallic oxids. It is made by dipping a platinum ribbon having a width of say 0.3 mm. (0.012 inch) and a thickness of 0.05 mm. (0.002 inch) in chromic or nitric acid, washing it in water, and then in a strong solution of ammonia. After this thorough cleansing, it is heated to incandescence to see if it has any defects. It may then be dipped in a trough filled with dilute strontium hydroxid and thereafter dried at 100° C (212° F.) by a current of

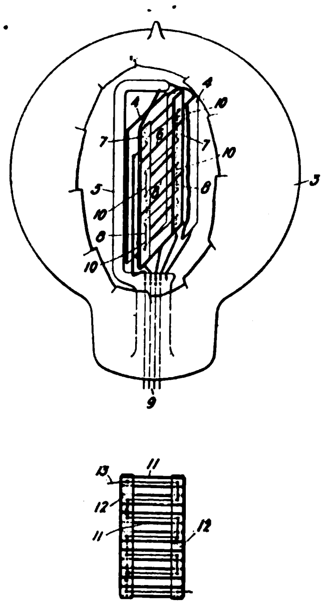


Figure 197—Western Electric Company-van der Bijl amplifier tube, 1915

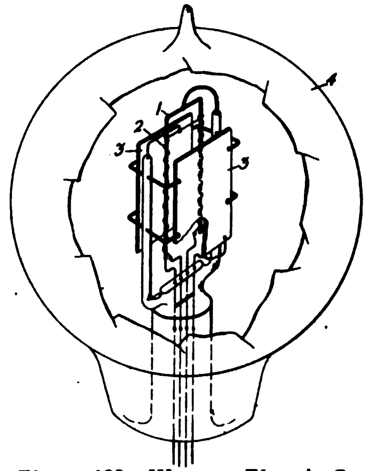


Figure 198—Western Electric Company-Nicolson amplifier tube, 1914

1.4 amperes. After four such coatings, the filament is heated to incandescence for a few seconds to harden the oxid film. It is next coated with barium resinate melted at a temperature of 600° C. (1,100° F.), and given four coats thereof as before except that it is heated for a few seconds to incandescence after each coat or two. The entire process thus far mentioned is then repeated, thus giving four sets of four coats of the oxid or resinate in all. The filament is then kept at incandescence for about 2 hours at 800° C. (1,470° F.) to ignite the resinate. The resulting film of strontium and barium oxids on the filament is smooth and tough and gives high electron emission at comparatively low temperatures thus tending to give a long filament life in use. Tubes of this sort, but with a grid and plate at each side of the filament, are widely used by the Company.

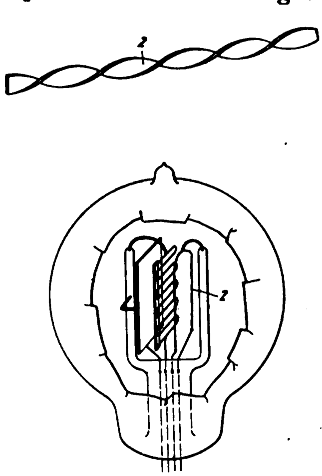


Figure 199—Western Electric Company-Nicolson-and-Hull amplifier tube, 1914

One type of receiver used by the Western Electric Company consists of a number of steps. The antenna circuit is coupled to a radio frequency regenerative amplifier, much like that shown in Figure 188 in most respects except that the output is obtained by coupling in the plate circuit to a fairly large impedance as in Figure 194. The next circuit is a detector circuit, also provided with regenerative coupling. The output of this step passes into a two-step audio frequency amplifier with inductive coupling between the steps. The final output is inductively coupled to a balanced receiver for reducing the relative intensity of strays, and devised on somewhat the same general lines as that shown in Figure 9 except that three-electrode tubes are used.

The General Electric Company has constructed a number of different types of pliotron amplifier tubes,

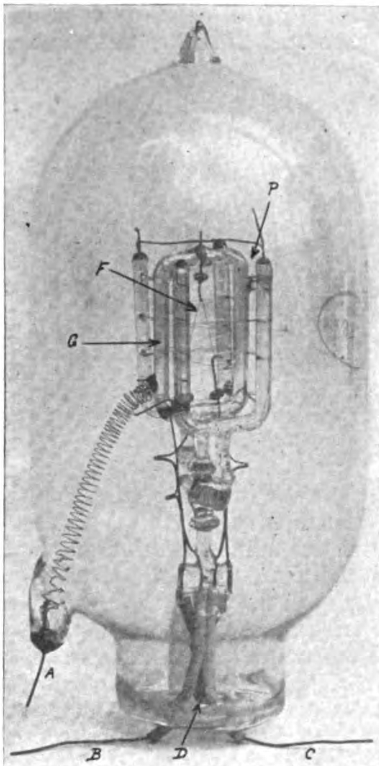


Figure 200—General Electric Company-White small pliotron amplifier

one type of which intended for relatively small outputs is shown in Figure 200. The grid *G* is made of very fine wire wound on a glass frame. Inside the grid is the "V" or "W" shaped filament *F*. The plate *P* is not a solid plate of metal, but consists of a zig-zag wire supported on wire supports placed appropriately in two "U" shaped glass frames. The filament leads are *B* and *C*, the plate terminal *D*, and the grid terminal *A*. The whole structure is carefully built and exhausted to an extremely high vacuum at which "pure electron" effects are obtained. Under these conditions it has been found possible to obtain extremely high audio and radio frequency amplifications without using regenerative circuits in connection with the bulb, that is, without any other coupling between grid and plate circuits than the small capacitive coupling which necessarily exists within the bulb.

Mr. Alexanderson has shown several methods whereby a number of such tubes may be used in cascade, each giving radio frequency amplification. It is claimed that the selectivity of the resulting system is high, rising in geometric proportion to the number of steps.

This is the fourteenth of a series of articles on "Radio Telephony," by Dr. Alfred N. Goldsmith. In the fifteenth and concluding article, to be published in the March issue, Dr. Goldsmith discusses strays, range in radio telephony, radiophone traffic and its regulation and duplex operation. He also gives examples of imaginary radiotelephone conversations.

Tuning and Wave-Length Changing of Wireless Transmitters

IN the early days of radio development in the United States, it was customary to tune a ship's transmitter to the natural wave-length of the antenna regardless of its length; also, the majority of transmitters were very closely coupled, causing the antenna to radiate two waves. While this was not a desirable condition in the majority of cases, in certain instances it was of real benefit, because if the operator receiving experienced interference on one of the waves radiated by a given transmitter he could retune his equipment to the other wave and thereby receive signals. It is interesting to note that although considerable interference was caused by this double wave emission, it was often found that the decrement of the longer wave was far within the limit of the present-day Government restrictions.

At the time when the United States Government signed the articles of the London Convention, all ships were retuned and adjusted to the standard wave-lengths of 300 and 600 meters. It was somewhat difficult in some installations to reduce the natural wave-length of the antenna by means of the short wave condenser to the smaller value (300 meters) and in extreme cases it became necessary to erect a separate aerial for radiating energy at this wave-length.

A Digest of Electrical Progress

Unprecedented Demand for Power Station, Railway and Industrial Equipment—the Feature of the Manufacture of Apparatus During 1917—A Voltage Stabilizer Designed to Overcome the Fluctuations of the Line Voltage Where Electric Lights and Motors are Fed from the Same Source of Power—Practical Uses for the Kenotron Rectifier.

Developments in the Electrical Industry During 1917

THE expansion in the manufacture of electrical apparatus during the year past has been unprecedented. Due to the demands of war, laboratories of the various electrical manufacturing concerns throughout the United States have been placed under unusual pressure, and for obvious reasons, the nature of many practical inventions of unusual merit cannot, for the present, be disclosed. But it is certain that when the curtain is drawn aside after the war apparatus or machinery of great usefulness will be available for commercial enterprise.

When, in the fullness of time, the complete story of the developments in electrical industry for 1917 is told, it will constitute a record of which the entire electrical fraternity may well be proud; but at present, for reasons which will be appreciated by every American engineer, many items of interest must of necessity be omitted from any review covering the accomplishments of the industry.

So says John Liston in a recent issue of the General Electric Review.

The writer says that the feature of over-shadowing importance was the enormous increase in the volume of production of standard apparatus to meet unprecedented demands for power station, railway and industrial equipment. For certain types of apparatus which had long been in general use, this increase actually represented advances of several hundred per cent as compared with the maximum output of preceding years. Among the power apparatus of unusual proportions designed by the General Electric Company is mentioned a 35,000 kw. Turbo-generator, a 20,000 kv-a. 6,600 volt 60-cycle alternator, and a 50,000 kv-a. 60-cycle transformer for increasing a current of 12,200 volts to 24,400 volts. The latter instrument had a full load efficiency of 99.4 per cent.

An interesting device known as a voltage stabilizer for alternating current circuits is described. This device was designed to overcome the fluctuations of the line voltage where electric lights and motors are fed from the same source of power.

The stabilizer is essentially a highly reactive transformer having a primary through which the motor current flows and a secondary which is connected in series with the lamp load and boosts by an amount proportional to the voltage drop caused while starting. A photograph is shown in figure 1, and the theory of its operation is disclosed in figure 2.

A description follows:

It consists of a laminated core into which an adjustable airgap has been interposed. On the middle leg of the core structure are interwound the motor and lamp coils. When starting, the rush of current through the motor coil excites the magnetic circuit of the stabilizer and induces a voltage in the lamp coil which is substantially in phase with the lamp voltage. This action is

Figure 1—Voltage stabilizer for alternating-current circuit.

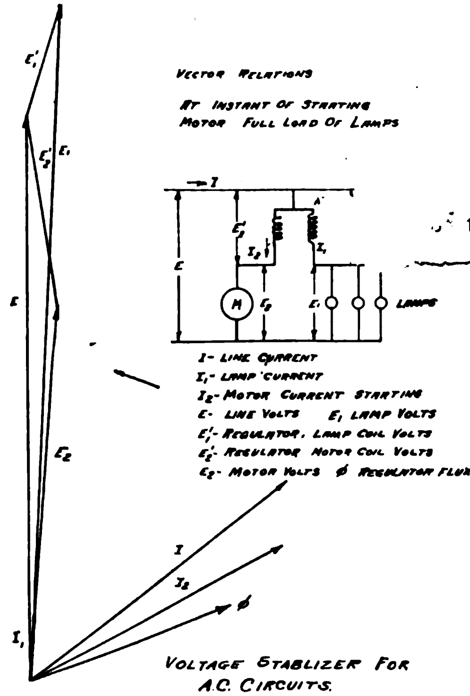


Figure 2.

shown in the diagram (Figure 2) where E is the voltage added vectorially by the lamp coil in order to maintain E_1, the lamp voltage, at a constant value. If, however, a transformer or reactance is inserted permanently in series with the motor its terminal voltage is appreciably lowered and this might be detrimental, since in some cases full load could not be delivered. In the stabilizer this effect is overcome in two ways: First, by designing so that at normal full load running current the flux density in the iron core is low—this means a correspondingly low voltage drop; Second, by inserting an air gap in the iron core the apparatus is made highly reactive and most of the drop over the motor coil is in quadrature with the line voltage, except for copper and core loss. These losses can and must be kept low in order to make the apparatus efficient.

Special notice is given to the work of the research laboratory and its development of a portable X-ray outfit that should prove of great service to our army. This equipment consists of a single cylinder, air-cooled gasolene engine, with direct connection to a 1 kw. direct current generator provided with slip rings so that current at a frequency of 47 cycles is applied; the carbureter of the engine is controlled through a solenoid and the necessary changes in speed are effected by means of a simple resistance unit located at the head of the operating table when the outfit is being used.

Due to the rectification characteristic of the Coolidge X-ray tube, no separate rectifier is required. The entire equipment, including the operating table, can be rapidly assembled or taken apart for transportation, the complete set having a net weight of 850 pounds.

The kenotron rectifier, which in reality is an enlarged form of Fleming's vacuum valve tube, has found two practical usages during the year. The first of these was in connection with the process of precipitation by means of high vol-

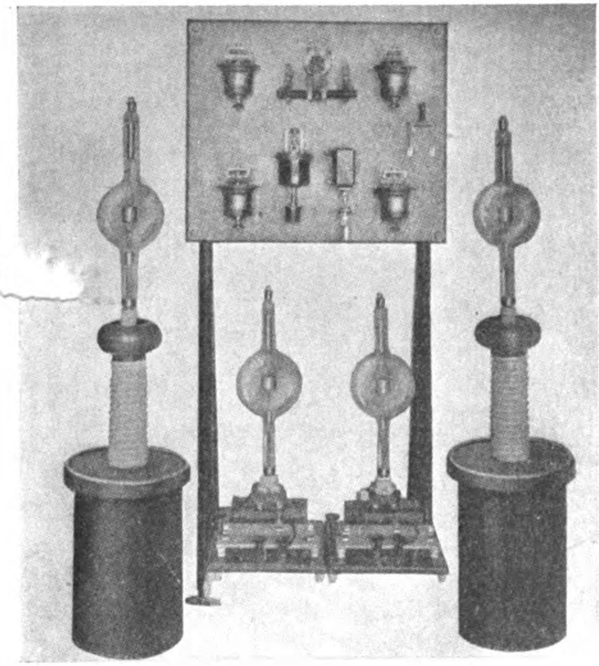


Figure 3—Switchboard Panel with protective devices for use on kenotron precipitation outfits, with filament transformers for kenotron.

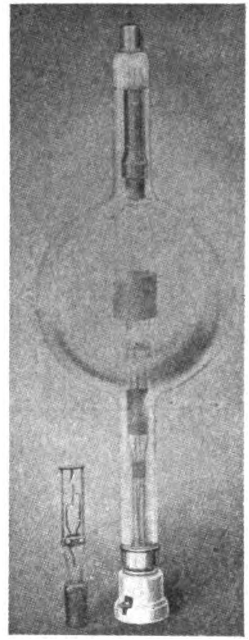


Figure 4—High-voltage kenotron.

tage direct current for the reclamation of usable materials in gases or smoke, or the abatement of the nuisance caused by the emission of noxious gases or smoke from flues or stacks. Direct current of high voltage is necessary for this work and heretofore it has been obtained by a mechanical rectifier which included several undesirable features which the kenotron rectifier eliminates. In addition, the mechanical rectifier imposed an undesirable strain upon the high voltage transformer.

The kenotron rectifier is noiseless in operation and the rectification is nearly perfect, with maximum voltage fluctuations of less than fifteen per cent delivering direct current of 100,000 volts. The complete switchboard fitted with kenotron precipitation outfit is shown in the diagram, figure 3, and a high voltage kenotron in figure 4. It should be remembered that the operation of the kenotron rectifier is perfect on voltages up to 100,000 volts, and as such it gives perfect rectification.

The kenotron found another application in the development of a cable testing set for supplying direct current of potential up to 60,000 volts.

The tungar valve rectifier, introduced to the trade some months ago, has found use in an astonishing number of ways. These rectifiers are applied in charging, starting, and lighting batteries on automobiles, motor-boats, motorcycles, in private and public garages, in groups as high as ten batteries, many public garages having from three to five rectifiers in service. They have also been utilized for charging the batteries required for the operation of clocks, telephones, fire alarms, etc. and for track and motor batteries on railway signaling systems. Tungar rectifiers are now built in sizes from .1 ampere and 7.5 volts up to 15 amperes and 108 volts, with many intermediate sizes and voltages.

Static condensers for correction of the power factor on commercial power lines have been developed to a point of great satisfaction. These condensers consist of groups of condenser sections, each made up of layers of tinfoil assembled

in oil in metal containers. The sections are individually fused and in addition, an oil switch is provided for connecting to or disconnecting from the line.

It was found that when condenser sections were connected directly across the line no improvement in power factor was secured, but that by inserting a small reactance in series with the condenser the use of practically the entire capacity of the condenser sections for power factor correction was possible.

As compared with the synchronous condenser, the static condenser shows exceedingly high efficiencies, the losses being less than one per cent of the total kv-a. regardless of capacity.

This condenser, of course, weighs less and occupies less space for a given capacity than a synchronous condenser, and since it possesses no moving parts, it requires practically no attention.

A number of mechanical and electrical devices, which mark distinct progress in the electrical art, are described in detail.

The Production of Nitrate by the Electric Arc

THE production of nitrogen from air by the electric arc is a process which has been carried on for a number of years. The principal nitrate works are situated in the southeastern part of Norway in the Telemark river district. Approximately 60,000 horsepower is employed.

One of the best known systems by which nitrates are obtained is known as the Birkeland-Eyde process. In this process, nitrous gases are separated from the air by the formation of an arc between the points of electrodes, which are placed close to each other in a strong magnetic field. In a recent issue of the Electrical Review the process of generation is described as follows:

The electric arc that has been formed moves on account of this powerful magnetic field with great velocity perpendicularly to the lines of force, so that the arc is lengthened and finally broken. As the length of the arc increases the resistance becomes greater and the tension increases, until it becomes so great that a new arc starts from the points of the electrodes. In order to regulate the current an inductive resistance is used in series with the arc. With alternating current all the arcs are formed in opposite directions and appear to the eye to be circular disks. This flame provides a very effective means for the oxidation of the nitrogen of the air. The flame in the furnaces burns with a steadiness that is really astonishing.

The electrodes are thick copper tubing, through which water passes for cooling purposes. The furnace chamber in which the flame burns is circular, of only a few centimeters in width, and about three meters in vertical diameter. The furnaces are lined with fire-clay brick, through an opening in which the air is admitted to the flame. The nitrous gases formed in the flame escape through a channel made along the casing of the furnace, which like the flame chamber is lined with firebrick.

Each furnace is furnished with an induction coil by means of which the power is regulated as required. The induction coil serves, moreover, to keep the flame in the furnace steady and even while working. It is claimed that with this furnace there was obtained such steady working that it burns for weeks without any regulation worth mentioning. The maintenance of the furnace and its repairs are simple, as the most exposed portions, the electrodes, need be changed only every third or fourth week, and then but a small part of them. The firebrick masonry is changed every fourth to sixth month.

The temperature in the flames exceeds 3000 degrees centigrade.

The temperature of the escaping gases may vary between 800 and 1000 degrees. The furnaces are made of cast steel and iron, the middle of the furnace being in the form of a circular flame chamber. The electrodes are led radially into this flame chamber. By aid of centrifugal fans the air is brought into each furnace through pipes from the basement. Furnaces have been built consuming energy from a few horsepower up to 5000 horsepower.

The furnace just described has been improved upon by Dr. Schoenherr, and an electrical engineer named Hessberger, of the Badische Company.

The Schoenherr furnace in its present form consists of a slender vertical column of iron plates 7 meters in height, in each of which is developed a long slender arc in the axis of a narrow iron tube through which a current of air is forced. The inner tube is the reaction chamber, the others form channels for the entrance of the air current and its exit after coming in contact with the flame. In this manner, the heat of the outgoing gas comes in contact with the ingoing current.

At the lower end is the main electrode which is movable in a vertical direction, as it must be raised from time to time when the end is worn away by the arc. The reaction tube serves as the second electrode. By means of a lever the space between the electrode and tube can be bridged over and the arc formed. The air current, forced by a powerful aspirator, enters the lower part of the furnace and passes through the various channels. The entry into the reaction chamber is through a number of small tangential openings arranged in several horizontal rows in the sides. The current passes in this way around the chamber and the arc is driven up in the midst of the rapidly moving current of air.

The final process by which the nitrogen gases are cooled and absorbed is of interest. When the air in the flame chamber has been acted upon by the electric current, the nitrous gases generated thereby pass out through pipes into steam boilers where their temperature is reduced.

Air compressors, which supply air at considerable pressure, pump acid and lye into the various chemical departments. The gases pass from the steam boilers through an iron pipe into the cooling house, where the cooling which is begun in the steam boilers is completed.

The coolers consist of a great number of aluminum tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is thus considerably reduced.

The next step is to pass the gases from the cooling chambers into the oxidation tanks. These are vertical iron cylinders lined with acid-proof stone. In these the cooled gases have a sufficient period of repose in which time the complete oxidation of the nitrogen oxide may occur. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces.

The process from this point on is described as follows:

From the oxidation tanks the gases are forced by blast engines into the absorption towers. Broken quartz which is affected neither by nitric gases nor by nitric acid, is used in the towers. To assist the passage of the gases on their way from the furnaces there are centrifugal aluminum fans on each row of towers. The gases enter at the base of the first tower, go up through the quartz packing and thence by a large earthenware pipe enter the top of another tower, and so on, until the air, relieved of all nitrous gases, leaves the last tower.

Water trickles through the granite towers and by absorbing the

nitric oxides is gradually converted into a weak acid. The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases enter into intimate contact with the liquid. Nitric acid is thus formed in the granite towers. In the iron towers a weak solution of caustic soda is used which on absorption of the gas is converted into a solution of nitrate of soda.

Further application of this process is bound to follow hydro-electric developments throughout the various countries.

Vacuum Valve Rectifiers for Charging Storage Batteries

THE rectifying properties of the Fleming valve have been employed for a number of years in connection with the receiving apparatus of a wireless telegraph system, but little use has been made of rectification in connection with low frequency currents. The General Electric Company has recently placed on the market, however, a simple vacuum valve rectifier, known as the Tungar, which is applicable to charging storage batteries from alternating current. It consists of a hot cathode and anode, the bulb being supplied with argon gas. In variation to the usual form used in radio, the anode in this valve is made of graphite.

In operation the filament of the rectifier is connected to an ordinary lamp socket, the two remaining connections of the complete rectifier to the storage battery under charge. When the tungsten filament is lit to incandescence there is a purplish glow between the cathode and the anode, and as usual in devices of this kind, a current of electricity can pass from the anode to the cathode, but not in the opposite direction. A rectified current therefore flows through the storage battery.

With these rectifiers it is possible to charge small storage batteries such as are employed in miners' lamps, inspectors' lamps, dentists' lamps, exit lights, electric piano players, burglar alarms, railroad signals, motor cycles, etc.

The Tungar rectifier is made in three sizes, and all are of the half-wave type with different amperage and voltage capacities. The 2-ampere unit, operated on 115 volts, 60 cycles, will charge three storage cells at 2 amperes, six cells at about 1 ampere, and eight cells at about 0.75 ampere.

The 6-ampere, 7.5-15 volt unit will charge either three or six cells of lead battery at 6 amperes when operated on 115-volt, 60-cycle circuit.

The 6-ampere, 7.5-75 volt unit will charge three to thirty cells of lead battery at from 1 to 6 amperes.

In addition to providing direct current in localities where alternating current only is available, the rectifier may be used for charging the storage battery of an automobile during the idle periods of the winter. In other words, the loss in charge due to the slight use of the automobile during the winter months can be compensated for during the night hours by permitting a small charge to pass through the battery.

The operation of the device is simplicity itself. The charging is accomplished by connecting the two leads from the rectifier to the storage battery; the red lead on the rectifier connects to the positive pole of the battery and the other to the negative pole. The lamp plug is then screwed into the nearest lamp socket and the switch turned on. Continuous charging is assured so long as the filament is lit to incandescence.

The cabinet in which the Tungar rectifier is mounted includes an ammeter, switch and current regulating handle, located on the front of the case.

Novel Buzzer Practice Set for Government Schools

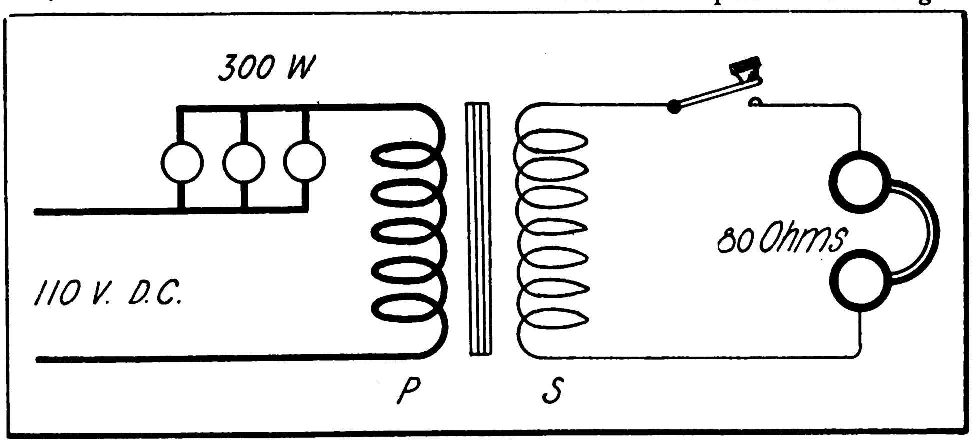
Paul G. Watson.

THE accompanying diagram shows the connections of the apparatus used for code practice in the radio school for drafted men in West Chester.

The source of current is 110-volt direct current mains. The bank of lights consists of three or four 100 watt carbon bulbs or their equivalent in smaller bulbs.

For efficient operation, an iron core must be used. The core for this coil consists of a tightly drawn bundle of No. 22 Norway iron wires, the bundle being about 9/16 inch in diameter. It is slipped inside of the primary tube, leaving ½ inch projection beyond the ends of the coil windings.

The coil is then placed in a rectangular case similar to a spark coil box and covered with insulating compound.



Novel buzzer practice set

The induction coil consists of two layers of No. 18 D. C. covered magnet wire, wound for a distance of 7½ or 8 inches on a fiber tube with an inside diameter of ¾ inches and an outside diameter of 1 inch. The terminals of the primary are brought to binding posts on the case of the coil and are marked "Primary."

The secondary winding is put on after the primary has been covered heavily with insulating varnish and several layers of empire cloth have been added. It consists of about ¾ lbs. of No. 26 D. C. C. magnet wire wound evenly over the empire cloth in several layers. The terminals of this winding are taken to binding posts on the coil case and are marked "Secondary."

After the insulating compound is hardened the primary is connected in series with the bank of lamps. The telephones are shunted across the secondary with the key in series. When the current is turned on and the key depressed a note similar to the pitch of NAA is produced in the receiver. One of the advantages of this system is that when the key is pressed no "click" is heard, but just a steady "buzz."

Do not have the telephone circuit closed when the power is turned on as the surge is strong enough to burn out the telephones. The telephones are of the ordinary 80 ohm telephone type and the key is a standard line telegraph key.

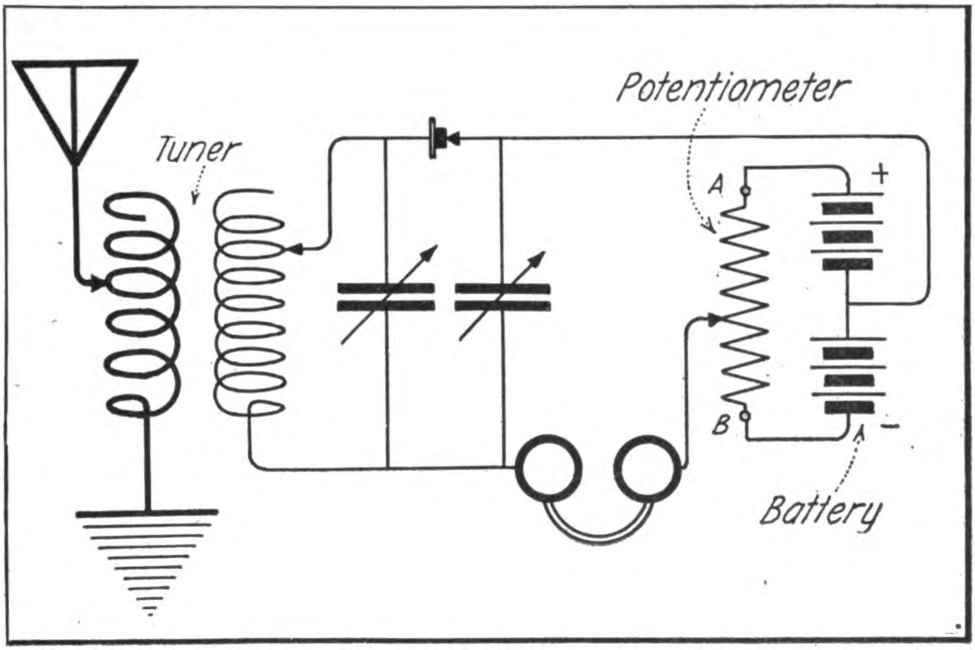


Figure 1—Current reverser, complete circuit

A Current Reverser for Crystal Detectors

MANY amateurs have been accustomed to install an elaborate current reversing switch for changing the direction of current through crystalline detectors, but they have neglected to employ a much simpler system, the circuits of which have been used in commercial wireless systems for a number of years. Either a positive or negative potential can be supplied to one side of the crystal detector by simply changing the position of the sliding contact on the potentiometer as will presently be shown.

In the accompanying diagrams, figures 1 and 2 are shown; first, the complete circuit, and, second, the construction of the potentiometer. In addition, it will be noted from figure 1, that the battery must be twice the size of that ordinarily applied in connection with crystalline detectors. In this diagram, a negative potential can be applied to the right-hand terminal of the telephone by sliding the contact to the top of the potentiometer (A), and a positive potential by sliding it to the bottom of the potentiometer (B).

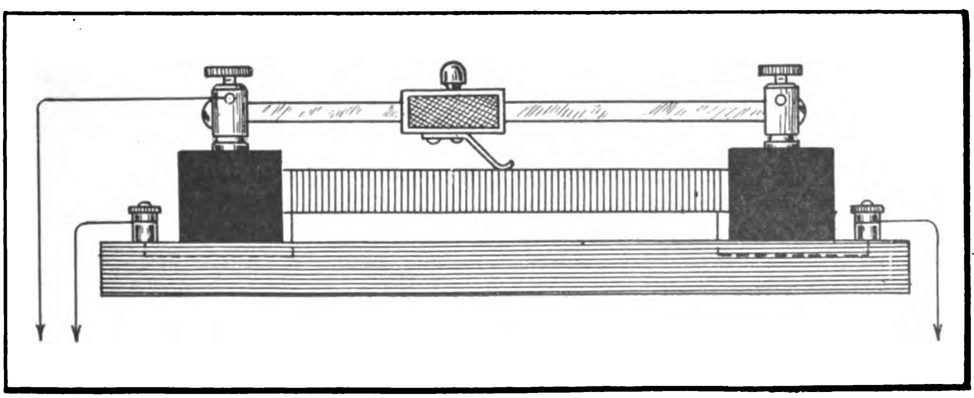
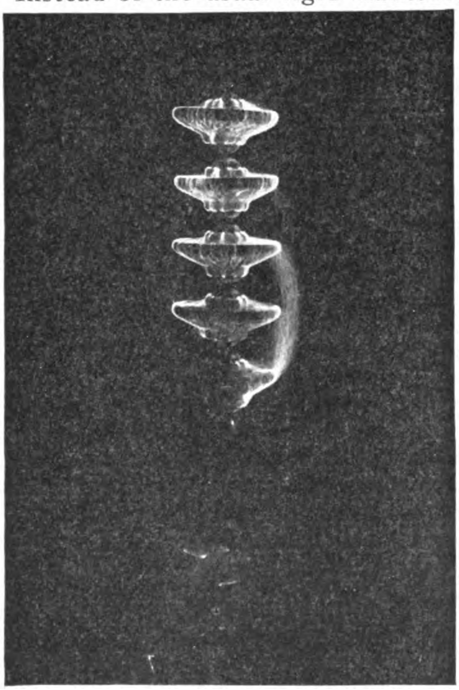


Figure 2—Construction of the potentiometer

A Remarkable High Tension Insulator

THE accompanying illustrations show a remarkable high tension insulator which several power companies have tested under oil, 200,000 volts being an average value for puncture strength of these discs. The puncture of some occurred at 300,000 volts. The insulators have stood high frequency flashover tests for one hour.

Instead of the usual rigid malleable iron caps and solid pins, two spider shaped caps are used, with eight legs fastened into the upper and lower sides of the insulator at a depth of 1 inch. The flexibility of the legs prevents expansion and contraction strains on the porcelain, absorbs shocks and distributes the tensile strain uniformly. No cement is used. The spider legs are anchored into recessed holes in the porcelain by means of a special alloy similar to that used in die casting. This alloy as applied does not shrink away from the porcelain and has a very low coefficient of expansion. The insulator will stand plunging from boiling to ice water without injury.



High tension insulator tested under oil up to 300,000 volts

Single unit of the high tension insulator

The construction described gives the disc an ultimate strength of 8,000 to 10,000 lbs. Electrical properties have been proven not to be affected in the least up to the full breaking strain, and the electrical and mechanical strains occur at entirely different parts of the porcelain.

The diameter of the unit is 11 inches, and the distance between units assembled is 6½ inches. The dry flashover tests of one unit at normal frequency showed 97,000 volts; with two in series the pressure was 184,000 volts, while three in series withstood 253,000 volts. In the wet flashover test (precipitation 1 inch in 5 min.) 50,000 volts was used and with two in series 92,000 volts; four in series withstood 185,000 volts, and with five in series the pressure was 220,000 volts.

It is stated that the high frequency oscillator test gave a first arc-over value with one disc of 120,000 volts, and with five units in series 500,000 volts. In testing insulators each unit is mechanically tested to a strain of 5,000 or 6,000 pounds, then it is tested electrically to flashover for ten minutes on a 60-cycle transformer with a high frequency oscillator for 250,000 volts. As soon as this is finished the disc is tested on high frequency, as it is better to find the weaknesses before putting the insulators on the line than afterward.

This insulator, once it is put up, will not have to be taken down due to any di-electric or mechanical weakness. The di-electric thickness of this disc is 2¼ inches, against one-third this amount for single piece units in use

in the post. The stress on the porcelain under all operating conditions is correspondingly lower than on thinner types.

It has been proven that insulating materials gradually fail under stresses which cause corona. The critical stress varies with the specific inductive capacity of the material. For porcelain, the safe potential gradient is about 40,000 volts per inch thickness. It is held that the disc, as proven by tests, both on normal and high frequency, avoids corona up to 90,000 and even 110,000 volts, whereas a disc ¾ inch thick is under corona at 30,000 volts. Some experimenters claim to have observed it at much lower voltages.

This disc will insulate permanently, because of its safe di-electric stresses; the perfectly balanced field is also very important in securing the full value of the insulating material and enabling the insulator to resist high frequency and other line conditions caused by lightning and switching. In the cap and pin type the area of contact with cement outside is six or seven times that in the pin hole, causing a greatly concentrated stress on the porcelain nearest the pin hole.

Construction of a Buzzer Telegraph

WHILE the buzzer telegraph is not new, I think that a description of one will prove of interest to amateur wireless operators at this time. Many are apt to forego code practice during the war because it lacks the interest of actually communicating. The buzzer offers a simple, cheap and efficient method of communicating and at the same time obtaining practice.

The most prominent features of the device are the distance that can be covered and the simplicity and cheapness of the apparatus. It may be used either as a permanent or portable outfit, depending on how it is mounted. As most experimenters have all the materials needed, the cost will be next to nothing.

The following articles are needed:

1. A call buzzer.
2. A cheap receiver or phone.
3. A telegraph key.
4. Two or three dry cells.
5. A line connecting the two points or stations.
6. A ground connection.

The buzzer may be of the type used for adjusting mineral detectors or as a door call. A telephone receiver, "pony" receiver, or the 'phones from your wireless set can be used. The batteries may be dry cells or a 4-6 volt storage battery.

If you live in town you will possibly have to erect a line on 2 by 4's or through trees. The line does not need to be insulated. It may be of iron wire. In the country, the top wire of the barbed wire fence can be used. See that the line is continuous. An extensive ground connection is not required, a small pipe or rod driven into the earth a few feet serves excellently.

Connect the buzzer, key and batteries in series. Solder a flexible wire to the upright contact post of the interrupter, connect one terminal of the 'phone to this and the other to the line. Connect the ground wire to the binding post on the buzzer which leads to the coil of wire.

The U. S. Army Signal Corps has sent over 150 miles with the buzzer. A fellow "fiend" in a nearby town told me that he and a friend had a line a mile long and that when using a six-volt storage battery to work the buzzer they had to put a resistance in series with the line so that the signals in the receivers would not hurt their ears!

I have an outfit similar to the one I have described and have sent eleven miles over a country telephone line with it. I used one wire and a ground. Ordinarily, I use it to communicate with a friend about one mile away over a barbed wire fence. The signals come in very strong.

Harold C. Vance,
Washington.

Editorial Note.—The use of a shunt resistance is recommended, rather than a series resistance, to reduce the strength of signals.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A Short Wave Regenerative Receiver

I SHOULD like to present to the readers of your excellent magazine the complete drawings of a short wave regenerative receiving set which I have designed and used with excellent results. The general plan, including the placing of the various parts of the and the vacuum valve with the filament rheostat and switch for the high voltage batteries to the right. The reader's attention is called to the fact that the position of the filament rheostat has been left out of this drawing, but it is to be mounted on the front of the panel as shown in the right-hand part of figure 4.

Beginning with the panel, it can be

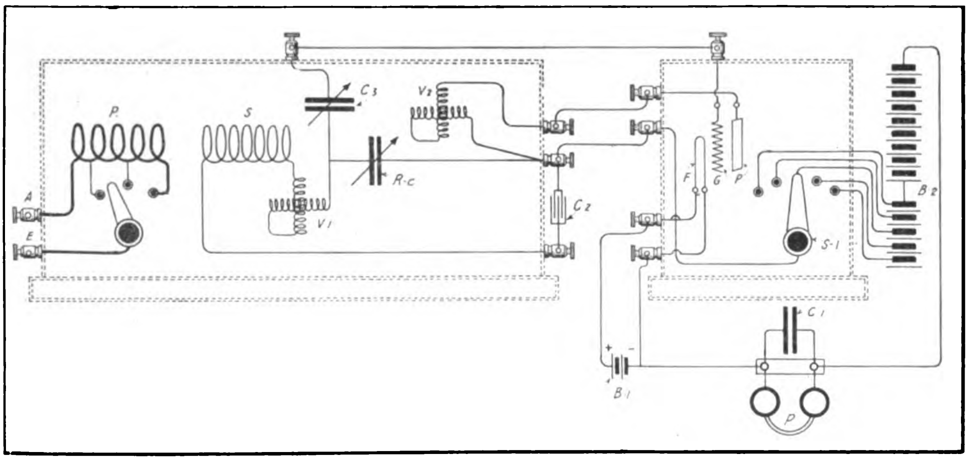


Figure 1—First prize article

complete apparatus is shown in figure 1, a fundamental wiring diagram in figure 2, a sketch showing how the coupling between the primary and secondary windings is adjusted, in figure 3, and the over-all dimensions and general outside appearance of the cabinet, in figure 4. Although primarily designed for reception at the wave-length of 200 meters, it was found that response could be obtained in this circuit at wave-lengths up to 800 meters.

It will be noticed first, that the primary and secondary winding of the receiving tuner, two variable condensers and two variometers are mounted on the cabinet, to the left of figure 1, made of black fibre and should have dimensions of 18 inches by 8 inches. The cabinet for the vacuum valve can be of any size consistent with the dimensions of the tube and, of course, it should have sufficient space to hold the high voltage battery (30 to 50 small cells).

The primary winding of the receiving tuner P (figure 1) is wound on a tube 3 inches in diameter by 1½ inches in length, containing thirty turns of No. 26 wire. The secondary winding is 2½ inches in diameter and 1½ inches in length, wound with 25 turns of No. 32 wire. No provision is made for variation of the inductance in this

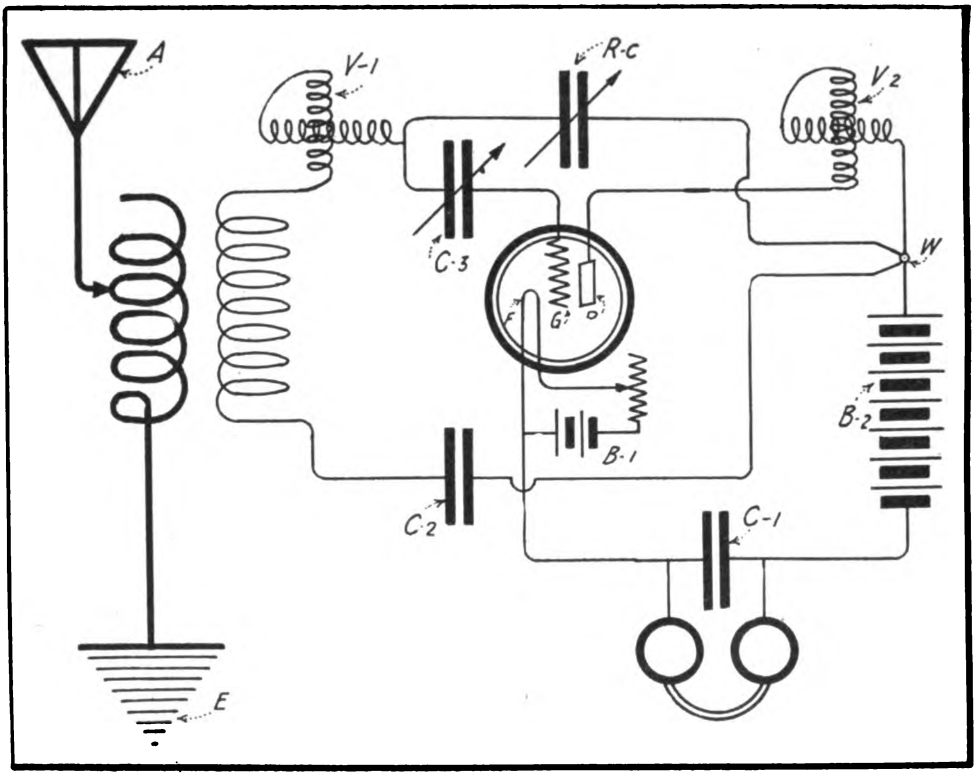


Figure 2—First prize article

winding as the necessary changes of frequency in the closed circuit are made by the variometer, V-1, and the grid condenser, C-3.

Each of the variometers, V-1 and V-2, in figure 1 have twenty-five turns of No. 28 B & S wire on each coil. The two variable condensers, Rc and C-3, should be of small capacity; in fact, they need not contain more than from three to five plates, each of the usual small size condenser. These can easily be made, or purchased from a wireless supply house.

After the reader has thoroughly noted the general outlay of figure 1, he should study the fundamental diagram of Figure 2 in which it will be observed that the grid circuit of the vacuum valve is tuned by the variometer, V-1, and the wing circuit by the variometer, V-2. One secondary terminal of the receiving tuner goes through variometer, V-1, through the grid condenser, C-3 to the grid G, and the other connection goes through the condenser, C-2, to the wing circuit at point W. By this connection the wing and grid circuits are electrostatically coupled through the telephone condenser, C-1, and an additional coupling is afforded by what is termed the "regenerative condenser," Rc, shown at the top of the drawing.

Further reference should be made

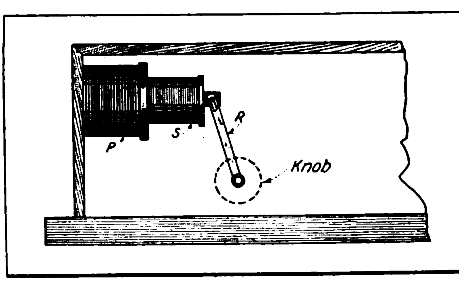


Figure 3—First prize article

to figure 4, in which the positions of the knobs controlling the variable condensers and variometers are clearly shown. Owing to the extreme sensitiveness of a circuit of this kind, it is

better to fit these knobs with long fibre handles from 6 inches to 8 inches in length so that the circuits can be tuned without changing the resonance adjustment by the capacity of the body of the manipulator.

Figure 3 shows how the primary and secondary coupling is varied by a knob. This is accomplished by a rod, R, which is attached to the secondary winding. The secondary coil slides on a rod in the usual manner.

In the adjustment of this apparatus it is best to first set the regenerative condenser, R_c, at zero and then tune the secondary and wing circuits witn variometers V-1 and V-2. After resonance is established amplification is obtained by careful adjustment of the condenser R_c. Condenser C-2 can be made of two or three sheets of tin foil 2 inches by 2 inches, separated by thin sheets of micanite 2½ inches by 2½ inches.

Surprising results are in store for the amateur who has never tried a circuit of this kind. Extreme selectivity is obtainable which is, of course, due to the regenerative feature of the apparatus which makes the circuit act much similar to an oscillation circuit of very small damping. The adjustments of the variable condensers or variometers for a given station are invariably exceedingly sharp. In fact, a movement of about 1/30th of an inch of the control knobs often will completely eliminate the signals.

The experimenter should take into consideration that it requires a certain amount of experience to get the best results from an apparatus of this kind, and in consequence, he should not be dissatisfied if the results at first trial are not to his liking.

Howard White, *California.*

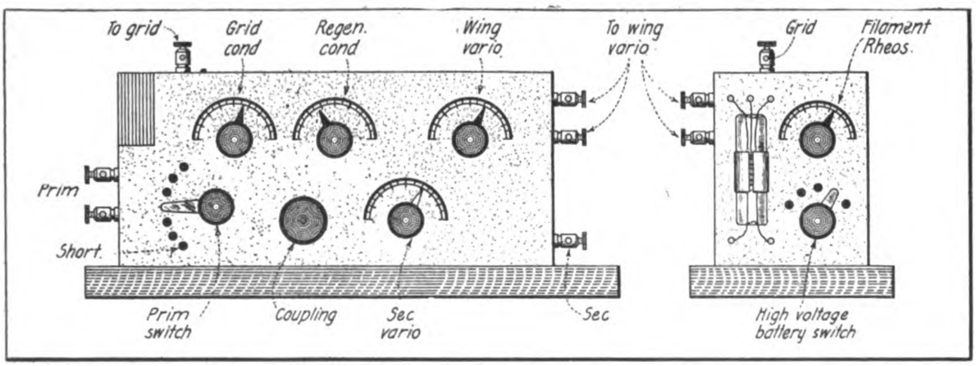


Figure 4—First prize article.

SECOND PRIZE, FIVE DOLLARS—A Simple Dead-End Switch

FROM time to time dead-end switches have been described in the various magazines, all of which will work in theory but in actual practice either fail to work at all or are so impractical as to necessitate their removal. I know, for I have tried some of them.

A practical dead-end switch must be of the type easily constructed because of the limited tool kit which the amateur possesses. Also, it must be rugged, easily repaired, and inexpensive. The one I am about to describe includes all these desirable features.

The knob, K (figure 1) is 1¼ inches in diameter and of composition. It is procurable at any radio supply house for 20 cents. The dial, D, is of bakelite or hard fibre 1/16th of an inch thick and 3 inches in diameter. The pointer, P, is shown at the top of the dial, but may be placed at either side and a scale scratched into the dial and filled in with a paste made of powdered chalk and glycerine. In assembling the rotating unit see that the washer, W, has both faces parallel and perpendicular to the hole. The washer may be a length of tubing with the hole threaded to fit the 2-inch machine screw B, or it may be an ordinary nut. Q and L are washers. Nut N is of brass and as thick as possible. On one face a hole is drilled as far as the center and

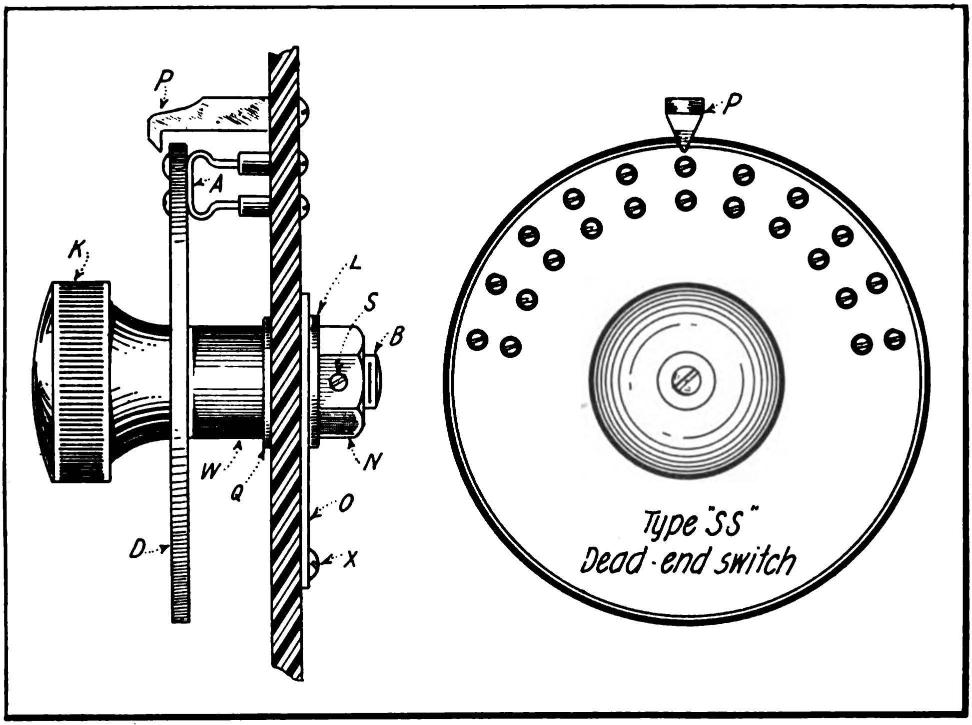


Figure 1 *Second prize article* *Figure 2*

tapped to fit the machine screw S which is employed to lock the nut onto the bolt B so that it *cannot* come off unless the owner unscrews S. No connections are taken from the nut, but are soldered to the brass plate O which is kept from turning by a screw X. The drawings (figures 2 and 3) explain the method of mounting the blades, A, which are of fairly heavy

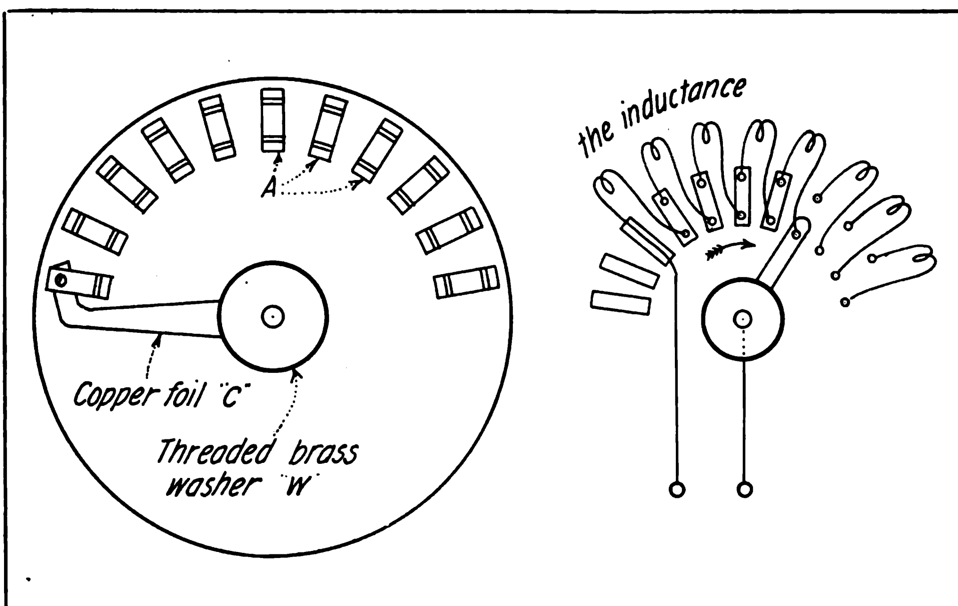


Figure 3 *Second prize article* *Figure 4*

spring brass or phosphor bronze and bent as shown in the end view. Each blade is fastened to the dial by two small machine screws (about 6/32 of an inch).

As raw material is rapidly advancing in price for the experimenter and decreasing in quality and amount, it is advisable to buy at once, even though the switch is not to be used for the duration of the war. A wiring diagram for the switch is shown in figure 4.

Francis R. Pray,
Massachusetts.

THIRD PRIZE, THREE DOLLARS

A Multi Detector

Of all the receiving detectors I have employed in practice I find the one shown in the drawing (figure 1) to be superior to any. It is to be noted in this diagram that the crystals are mounted with cups 1, 2, 3, 4, which, in turn, are mounted on a strip of 1/8 inch brass bent to shape as shown. An upright brass post, A, is mounted on the base; a square rod, B, carries a slider, C, which has a movement on rod, B, of about 2 inches. Mounted on slider C is a piece of elastic metal, D, which carries the contact point, E. Contact point E can also be slid back and forth on the strip, D, as shown at point F. Connection can be made to one terminal of the detector at binding post S and to the other terminal at binding post S-1.

The process of adjustment of this detector is self-evident from the drawing. Crystals of different kinds can be mounted in cups 1, 2, 3, 4, or crystals of various degrees of sensitiveness of the same kind. If crystal No. 1, for instance, becomes inoperative for any reason whatsoever, the operator needs only to pull on the handle, H, and place the contact point, E, on the surface of another crystal. Again, the pressure on the crystal can be adjusted by the knob, K, the rod to which it is attached being threaded.

If the crystal becomes "clogged" by induction from the local transmitter, it is only necessary to take hold of the handle H, raise the contact point E off the crystal and let it return to its original position. Usually, the necessary readjustment is secured immediately.

E. T. Jones, *Louisiana.*

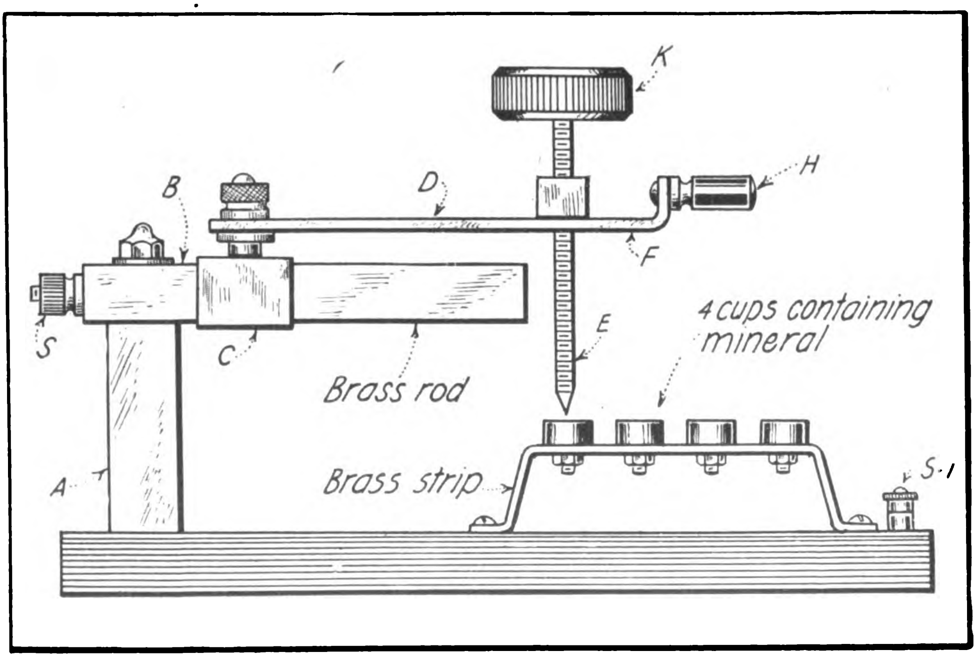


Figure 1—Third prize article

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

WHEN a letter addressed to an old-time amateur friend fails to elicit a reply, the possibility suggests itself that he is serving either in the U. S. Navy or with the expeditionary forces in France.

Almost daily, Association officials come in contact with former amateurs who must now be addressed as Radio Gunner Smith, Ensign Jones, Lieutenant Brown, Captain Hicks, and even Major Dobbs. That the majority of these men are highly qualified for the appointments they have obtained is due to the fact that many are college graduates who have had several years of practical experience in radio, or those whose contact with the art in a commercial and amateur way has well fitted them for their undertaking.

Although, so far as actual wireless experiments are concerned, the experimenter is prevented from carrying out a self-educating program at home, he still may secure the necessary practical experience by enrolling in a nearby radio school. Among such schools are those given permission by the naval authorities to operate apparatus with certain minor restrictions which do not hinder gaining a practical education. Numerous vacancies for expert wireless men exist in both Army and Navy. Young men who will shortly come to draft age should not fail to grasp the opportunities thus placed before them.

Full particulars regarding enlistment in either the Army or Navy can be secured from the nearest recruiting office. Skilled men are the requirement of the hour and experience has demonstrated that the recruit who advances most rapidly is the one who has had some practical experience in a wireless telegraph school.

Schools have been established by the U. S. Navy at New York and San Francisco for the purpose of furnishing both radio and general electricians from the enlisted personnel of the Navy. The pay of landsmen for electrician is $17.60 per month while under instruction, and in addition he is furnished with a complete outfit including a uniform, board and lodging, textbooks, tools, and materials with which to work. The length of the course is about eight months.

* * *

JUST now the atmosphere is far from being congested with a mixture of radiograms. Never were the seas so quiet; only essential business is being dispatched, and it is limited in quantity. Radio stations throughout the world are on the alert these days to intercept distress signals or other

urgent messages. There are always several vessels within range to effect a rescue, and a call for help never fails to bring response from a land station or coast patrol boat. Through the employment of supersensitive receiving detectors the range of wireless transmitters has been greatly increased, and a call for assistance may now be heard thousands of miles even during the daylight hours.

* * *

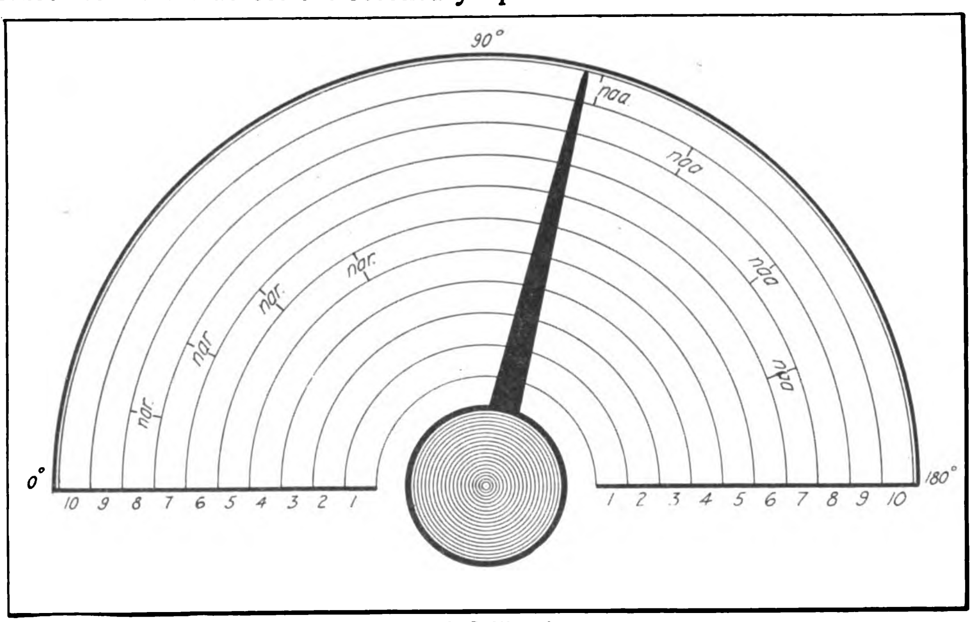
"WHAT constitutes a wireless telegraph equipment?" asks the over-zealous but still patriotic amateur. "Can't I purchase a detector or variable condenser, or construct a high voltage transformer without permission from the Government authorities?"

Positively, No. All or any parts of an apparatus which is eventually to be used in a wireless system come under the embargo, and cannot be constructed, bought, or sold until the end of the war. Should the experimenter desire to construct a piece of apparatus which *might* be used in a wireless system, but is intended strictly for another purpose, the necessary permission may be had by addressing the Communication Superintendent of the nearest Naval District.

The President's order must be strictly observed.

Practical Calibration of the Receiving Tuner

AMATEUR experimenters could work their apparatus with greater ease if they would calibrate the condenser connected across the secondary winding of the receiving tuner as per the accompanying drawing. It is well understood that owing to the different amounts of inductance that may be connected in the secondary circuit for a given wave length, different values of capacity must be employed for determining resonance. Hence, for each new value of the secondary inductance, the point of resonance will be found upon the variable condenser at a different angle of displacement of the plates.



Practical Calibration.

In the diagram, semi-circles 1, 2, 3, 4, 5 6, etc., represent the taps of the secondary inductance, and the notations NAR, NAA, represent the different points on which a station radiating a given wave length is heard with different values of secondary inductance. I highly recommend this plan to experimenters.

E. T. Jones, *Louisiana.*

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Positively no Questions Answered by Mail.

A. E. R.; Leavenworth, Kansas:

In the measurement of the specific gravity of gases, air is employed as the standard or unity (1). Accordingly, the specific gravity of hydrogen is .069. Hence, you should have no difficulty in conceiving why a balloon rises. Ammonia gas is much lighter than air, its specific gravity being .537.

In reply to your second query: when an oscillation circuit containing inductance and capacity is shocked by a transient electromagnetic disturbance such as a magnetic blow from a non-oscillatory voltage, the oscillations generated in the circuit acted upon are termed *free oscillations*. But if a suddenly applied *oscillatory* voltage acts upon the circuit, two currents are set up, one a *free oscillation* having the periodicity of the circuit, and the other a *forced oscillation* having the periodicity of frequency of the applied voltage.

The rotor speed of the Alexanderson 2 kw. radio frequency alternator averages 700 miles per hour, which, as you assume, not only must be in excess of the speed of the average express train, but actually is. Devices which revolve at 20,000 revolutions per minute are not common, and some of the conclusions you have arrived at are quite practical.

* * *

K. V. D., Bloomington, Ill.:

The efficiency and practicability of the vacuum valve as an amplifier of radio frequency currents overshadows the microphone relays to such an extent that it is doubtful whether the latter will ever see considerable commercial use. Radio frequency amplifiers are decidedly in the order of the day.

* * *

D. V. L., St. Louis, Mo., asks:

Ques.—(1) Please give me the dimensions of a Tesla coil which can be operated by a ½ kw. high voltage transformer with good results.

Ans.—(1) In the design to be given it is intended that the secondary winding of the Tesla coil shall be placed inside the primary, and that the spark discharge electrodes for the secondary will be placed at each end. The primary coil is 21 inches outside diameter, 8 inches in length, wound with 7 turns of No. 4 B. & S. bare, or D. B. R. C. wire. The secondary winding is 55 inches in length, 10 inches in diameter wound with No. 24 S. C. C. wire, which is spaced by the thickness of a thread. On completion, the secondary winding may be immersed in hot paraffin or in shellac. With sharp pointed electrodes mounted on the secondary terminals this coil should give a spark from 24 to 29 inches in length. The best results are secured by using all turns of the primary winding, but the tuning will be found rather sharp and it is best accomplished by variation of the condenser capacity rather than turns of the primary winding, provided such variation does not interfere with the power absorption of the high voltage transformer.

* * *

A. B. R., Minneapolis, Minn.:

A straight wire 1,000 centimeters in length has inductance of 1 henry.

For the practical purposes you require, the following simple formula will give the approximate correct number of turns for your transformer primary (closed core):

$$T = \frac{E \times 10^8}{N \times \Phi \times 4.4}.$$

where $\Phi = A \times B$
- A = the area of the cross-section of the iron core
- B = the lines of force per square inch
- E = the primary E.M.F.
- N = the frequency of the current
- Φ = the total lines of force.

It is suggested that you allow approximately 30,000 lines of force per square inch in this transformer.

J. A. R., New York City, inquires:

Ques.—(1) Please calculate for me the total magnetic lines of force in a toroidal coil of the following dimensions: The main circumference of the coil is 32 inches. It is wound on 64 turns of wire which pass 10 amperes of current. The cross-sectional area of the toroidal is 2 sq. inches and the permeability of the iron is 3,000 perms per inch cube.

Ans.—(1) The total lines of force

$$= \frac{N \times I \times A \times \mu}{1}$$

Where N = the total turns
I = the exciting current in amperes
A = cross-sectional area of right angles to the flux
1 = the length of the magnetic circuit in inches
μ = the perms per inch cube

Hence, the total lines of force

$$= \frac{64 \times 10 \times 4 \times 3{,}000}{32} = 240{,}000 \text{ lines.}$$

* * *

J. B. R., Chicago, Ill.:

In a single phase rotary converter maximum alternating current voltage is equal to the normal continuous current voltage. It can be shown mathematically that the effective value of an alternating current is .707 of its maximum value. Hence, if 110 volts are supplied to the motor terminals of a converter, 110 × 70.7 or 77.7 volts will be supplied by the generator assuming no armature losses. Owing to the resistance of the armature conductors, the normal A.C. voltage will be somewhat less—about 70 or 71 volts.

* * *

B. A. D., Washington, D. C., inquires:

Ques.—(1) In the practical operation of a receiving tuner, how does the operator determine the most efficient coupling of the receiving transformer? How can his attention be drawn by a transmitting station operating on a wave length different from that to which his receiving apparatus is tuned?

Ans.—(1) Obviously, the most efficient degree of coupling at the receiver is the one giving the loudest signal. If the receiving detector is adjusted to its maximum sensibility, the loudest signals are secured by merely changing the coupling and readjusting the inductance and capacity in the primary and secondary circuits of the receiving system.

Replying to the second part of your query, it is assumed that the receiving station when not actually taking signals from a transmitter, has its tuning transformer so closely coupled that a number of different wave lengths will be heard simultaneously. Or, on the other hand, if the transmitting operator has some knowledge of the approximate adjustment of the receiving tuner, he might change the wave length of his transmitter to that value and thus attract the attention of the receiving operator.

* * *

A. L. B., Chicago, Ill.:

Isothermal lines are those drawn on the map joining all points having the same temperature. These lines are practically parallel on the ocean, but not so on land, due to changes in topography and therefore the change in the slant of the sun's rays.

Isothermal, Isotheral, and Isochimental lines refer to **mean general, mean summer,** and **mean winter temperature.**

* * *

V. R. D., Vancouver, B. C.:

On the basis that the atomic weight of hydrogen is unity, the atomic weight of aluminum is 27.4, of copper 63.18, and of silver 107.7. Whether or not this data is sufficient to carry on your calculations, we cannot say, for you have not stated your problem fully.

A selenium cell of the type you request may be made as follows: Cover a strip of aluminum with amorphous-selenium. This combination is insensitive to light. Raise the temperature of the strip to 200 degrees and maintain it at this temperature for several hours. Then cool slowly.

By this treatment the amorphous-selenium is transformed into crystals, and is sensitive to light rays. If this strip is immersed in a conducting liquid such as acetone or oenanthol, into which a platinum wire dips, a cell is formed which, when exposed to light, exhibits an E.M.F. which varies as the square root of the intensity of illumination, and also inversely as the distance of the source. The selenium becomes positively, the liquid negatively, charged. This is a type of cell which Prof. Minchin employed to measure the radiation emitted by stars and planets.

What is known as the Peltier effect was demonstrated as follows: A bar of bismuth was cut in the center and a piece of antimony soldered to it in such a way that the two elements formed a cross. When the positive pole of a battery was connected to the antimony and the minus pole to the bismuth with a galvanometer in series, the needle of the galvanometer was deflected in such a way as to indicate a rise of temperature at the junction. But when the current through the couple of bismuth and antimony was reversed, the needle was deflected in the opposite direction, which indicated that the junction was cooled. This simply demonstrates the effects observed when a thermo couple is heated to a temperature above the surrounding air, or cooled to a temperature below the surrounding air.

D. B. C., Washington, D. C., inquires:

Ques.—(1) Does it make any difference in which direction a motor generator revolves?

Ans.—(1) It makes no difference in so far as the generation of alternating current is concerned, but in some machines the brushes of the motor are such that better contact with the commutator is secured with the motor revolving in a certain direction.

Ques.—(2) What is the best way of reversing the direction of a compound wound motor?

Ans.—(2) The precaution should be taken to reverse the flow of current through the armature only, the connections of the two field windings to the outside line remaining as before.

Ques.—(3) Is it necessary to use protective condensers on a motor generator the wires to which are enclosed in conduit?

Ans.—(3) If the conduit is thoroughly connected to earth, in general, the desired protection will be secured, but it is customary on commercial wireless telegraph transmitters to use protective condensers in addition to the metallic covering. Lead-covered wire is employed in marine installations for connecting up the low voltage circuits.

Ques.—(4) How can a buzzer be employed to make audible undamped oscillations in an ordinary receiving apparatus?

Ans.—(4) The method generally used follows: Excite a wave meter in the usual way by a buzzer and place it in inductive relation to the antenna system. If the buzzer vibrates at a very high frequency, very little sound interference will be secured in the telephone, and the incoming oscillations will be varied at an audio frequency.

Ques.—(5) Which do you consider the better method: to connect a crystal rectifier to the output circuit of a vacuum valve, or to connect a crystal rectifier in the secondary circuit which is coupled to the antenna, attaching the vacuum valve to the local circuit of the rectifier?

Ans.—(5) Either connection may be used, but reports indicate that the best results are obtained by first rectifying the oscillations through the crystal. It is then customary to shunt an audio frequency transformer around the stopping condenser, the secondary terminals of which are connected to the filament and grid of a vacuum valve. A small battery should be connected in series with the grid circuit to obtain the best operating characteristics of the valve.

* * *

A. L. R., Richmond, Va., asks:

Ques.—(1) Please recommend a publication which gives a simple explanation of the principles of electrical engineering, principally the operation and fundamental circuits of dynamos and motors.

Ans.—(1) Dynamos and motor are treated in an elementary way in the book, "Practical Wireless Telegraphy." The book entitled, "Electrical Engineering" by Rosenburg, Gee and Kinzbrunner, will be of some assistance to you. Copies can be purchased from Wireless Press, Inc., 25 Elm Street, New York City.

Ques.—(2) Can the magnets of a telephone receiver be remagnetized?

Ans.—(2) They can be remagnetized by the usual process and increased sensitiveness will be obtained if the telephones have had "rough" treatment.

* * *

P. B. D., Radio Operator, U. S. S. Roosevelt, writes as follows:

"I should be interested to know whether other operators have noticed a phenomenon which seems to me to be more than a chance. I have often observed, while working during the winter months in the North Pacific and Bering Sea in particular, that a decided change of weather such as from stormy to calm, and vice versa, invariably is accompanied by good receiving weather, i.e., no static or atmospherics.

"I have never seen this fact mentioned in radio literature and would like to know whether I am alone in my observation."

We have no comments to offer on this statement, but would be interested to hear if any of our readers have made similar observations.

* * *

J. A. R., San Francisco, Cal.:

The diameter of No. 12 wire in the S.W.G. gauge is .104″ or 2.64 centimeters, and at a frequency of 1,000,000 cycles per second its resistance is .0328 ohm per meter. The diameter of No. 44 S.W.G. wire is .0032″ or .0081 centimeters.

* * *

L. A. R., Seattle, Wash.:

The capacity of two concentric metal cylinders can be found by the following formula:

$$K = S \frac{L}{2 \log_e \frac{R}{r}}$$

Where K = the capacity in electrostatic units (divided by 900,000 to convert to microfarads).

R, r = the radii of the external and internal cylinders respectively in centimeters.

L = the length in centimeters of part of the cylinders overlapping.

S = the specific inductive capacity of the di-electric (unity for air).

The WIRELESS AGE

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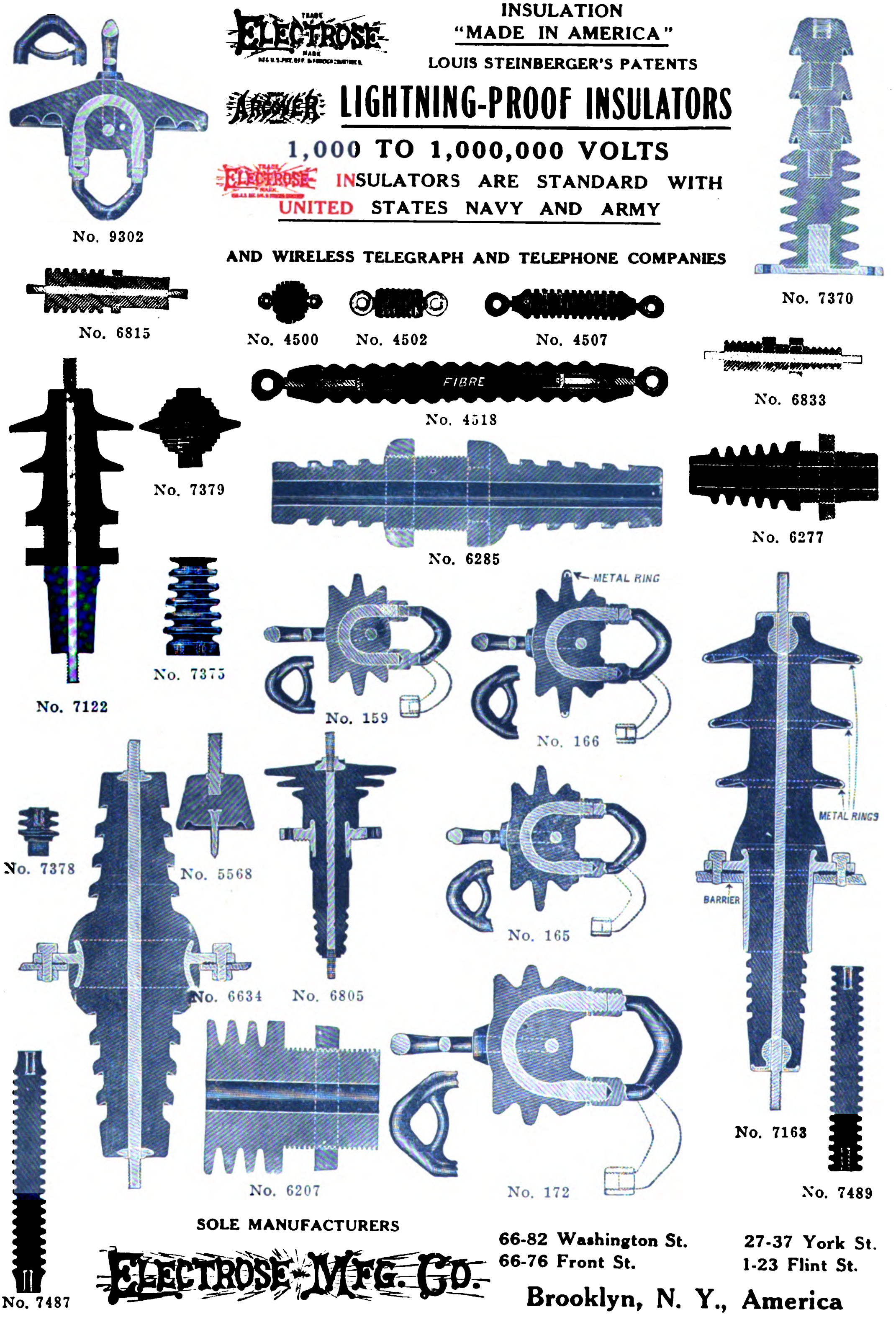

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No. 159
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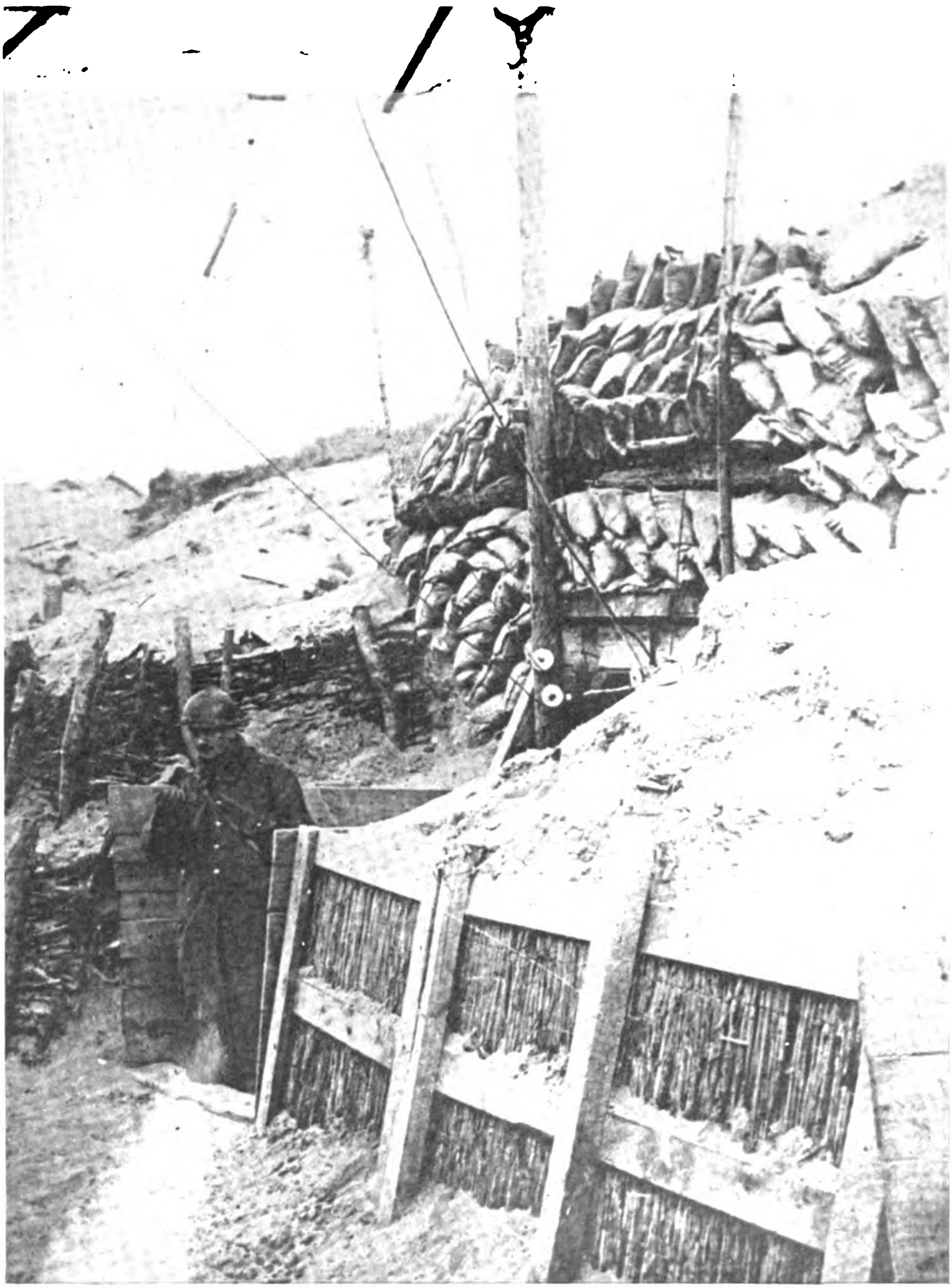


This view of a French wireless equipment in the second line of trenches is representative of the conditions awaiting American wireless men. The photograph clearly indicates the use of horizontal aerials suspended by pulleys for quick lowering. It is also worthy of note that the antenna is suspended but a few feet above the natural surface of the ground

THE WIRELESS AGE

WORLD WIDE WIRELESS

Marconi an Advocate of Allied Scientific Board

A VERY big suggestion to America and its allies has been made by Marconi, wizard of wireless and senator of Italy. Edward Marshall, a noted correspondent, to whom the inventor recently made the suggestion while in Rome, characterizes Marconi "one of the great doers of the world, as well as a great and startlingly developed thinker, and in this war, which so very largely is a war of science, he is a greater power than very many people know."

"One of the things which has been evident from the start of the great war," Marconi said, "has been and is the fact that the allies have not co-operated with complete effectiveness.

"I hope and I believe that the entrance of the United States will mean the start of real co-operation.

"Let the United States Naval Consulting Board become the model for an international committee of inventors and executives, which will mobilize the scientific thought and practical achievement of all our brains and hands in the service of the great cause of humanity!

"The great disinterestedness of the United States is what must most appeal to a fair European mind about the course which you have taken in entering the war.

"The American democracy is the greatest in the world. It has the vast material wealth necessary to the conduct of the greatest campaign ever made by any nation since the start of the world's history; that we know it has ideals and fights for them alone I have already indicated; it has developed an inventive genius which has given to humanity many of its greatest scientific and mechanical treasures, including steamship, telegraph, telephone, aeroplane, many of the engines of destruction which are utilized by both sides in this war."

Marconi was told how Edison was asked if he would head a committee for the accomplishment of this in case the government appointed one, and how he said he would, although at that time he was overburdened by the tasks which for a long period followed the great fire which almost wholly wiped out his works at Orange.

Marconi listened closely.

"We must have a similar board, at once, for all the allies," he declared emphatically.

"It would be a wonderful thing if it, also, might be under Mr. Edison's chairmanship. Surely it should have a real American as chairman.

"Thus, although its headquarters probably of necessity would be on this side of the ocean, it would be saved from some of the grave dangers of red-

tapeism which are so likely to surround European efforts at international co-operative organization."

"Would you co-operate fully with a board of that kind?" he was asked.

"I should be glad to," said Marconi.

"Would you serve as member of it?"

"I should be proud to," said Marconi. "Especially should I be proud to if at the head of the great board was Mr. Edison, the most honored son of wonderful America, and loved citizen of all the decent world.

"Now when the allies are confronted by the desperate necessity for real co-operation, the most intelligent model for its development in the scientific aspects of the war is found in the United States."

Of course it will be necessary to select a meeting place somewhere in Europe, for that could be near to the actual battle line, while an American city could not be, and because in Europe there are many allies, while the United States is one.

"Each contributing nation would need to appoint delegates with power and to furnish them with means unstintedly for carrying on new work, as well as with full facilities for learning everything that has been done by every friendly nation, and, as far as possible, the achievements and the failures of the enemy.

"What service such a board might render! Consider, for example, the splendid British tanks. They were infinitely valuable from the start, but it was months before any one of Britain's allies knew anything about them. Indeed that they should have known was quite impossible because of the lack of any medium through which they could be safely and intelligently informed. There have been other episodes as striking.

"Wireless has done much, but is capable of doing more. Too many good minds cannot be trained on it; it is worth the greatest mental effort and experimental industry. These, all, are problems of the sea, and there are many more which do not come into my mind.

"There are as many upon land. There wireless plays a large part, too, and might play an infinitely larger one."

Holland Has Long-Range Station

JAVA and Holland are now in communication by wireless over a distance of 10,000 miles. A. P. A. Kissing, business man of Batavia, is authority for the statement that the de Groot station at Bandoeng, Java, is transmitting 5,000 words daily to Scheveningen, a seaside resort of The Hague.

Owing to differences between the British and Dutch Governments, regarding alleged exports from Holland to Germany, the British refused to pass cablegrams to the Dutch East Indies, and Java and Holland were left disconnected.

Thereupon the matter was submitted to de Groot, already famous for his experiments in wireless telegraphy. He built a high-power station at Bandoeng, near Batavia, 2,800 feet above sea level, and soon got into touch with Holland.

Hun Humor In Wireless Defiance

COMMANDERS and crews of the American destroyers operating in European waters are talking about a grim piece of Hun humor. Nearly every night the commander of one of the destroyers receives by wireless a message reading:

"My position is (so many) degrees north and (so many) degrees west.

Come and get me. I'm waiting for you." The message is always signed "Hans Rose."

Rose is the German who took a submarine into Newport two years ago. According to the story passed around by the men engaged in the thrilling and hazardous task of seeking submarines, the captain to whom is directed the nightly messages of the German sub-sea craft, sank two. The commanders of both were intimate friends of Rose. He has sworn vengeance.

It is disquieting for the American commander, but he has no fears. Twice, it is stated, he has swiftly guided his craft to the location described by his enemy, but has found nothing. Still the mysterious wireless dispatch comes every night, no matter where the destroyer may be. Others catch it, and thus the weird story is told wherever the hornets of the sea are seen.

France and America To Perfect Overseas Communication

THE Navy Department is erecting a high-power radio station in France at a cost of $2,250,000, which will be ready for operation in August next. The French government will take it off our hands after the war is over. It will be used in connection with the great station fast nearing completion at Annapolis, which will be greater than the one at Arlington, Va. The present French stations are not powerful enough for communication across the Atlantic Ocean, being of about the same power as the station at Arlington. All of the equipment and structural parts are being made in this country for the foreign station. A station is also being built in Porto Rico. The British are establishing a high-powered station in the Azores, which will be valuable as a relay station. At present about 30,000 words a day are possible by wireless, and the new station at Annapolis will add 50,000 words per day. The greater part of the communication at the present time is by cable. If the cables are cut, it is estimated that the Annapolis station and Sayville and Tuckerton would probably be able to take care of all absolutely necessary military business. There is but little necessity for the use of the Pacific coast stations at this time, as practically all of the naval operations are on the Atlantic coast.

Victor Makes Records

ONE of the many problems of the War Department at the present time is that of securing a sufficient number of competent wireless operators, and arrangements have just recently been made whereby the Victor Talking Machine Co. in co-operation with the Marconi Institute will issue a special set of records to be used for purposes of instruction.

These instruction records were primarily prepared as a part of the courses offered to radio students by the Marconi Institute of New York.

Owing to the unusual demand for skilled telegraphists, in the United States Army and Navy, the institute quickly realized that it would be almost impossible to provide training facilities rapidly enough to meet conditions brought about by the war. To meet this emergency this series of lessons on Victor records was prepared in order that students might have the much more frequent opportunities and all the facilities for study which can so readily be afforded by the Victrola, either at home or in camp.

Those who have experimented at all with wireless know that it is rather more difficult to receive correctly than it is to send. The sending operator at least knows what it is that he wishes to say, and it is easy to understand how valuable these Victor records will be to the student.

In the ordinary way it is necessary to have two people at work before the student can get any practice. There must be someone to send as well as

someone to receive, and this difficulty is at once obviated by the use of the records.

Another even more valuable feature of the records is that they afford the student ample practice in receiving under all sorts of "interference." The operation of several wireless instruments in the same area produces a confusion which is known as interference, and which greatly increases the difficulty of receiving correctly. By means of the records the most serious "inerference" conditions can be so arranged that the student, through practice, may readily become expert under the most adverse conditions.

The Cipher Message Which Foretold Lusitania's Doom

THE cipher message which proved that Berlin directed the sinking of the Lusitania is made public for the first time in the World's Work. John R. Rathom, editor of the Providence Journal, which exposed numerous German plots in this country during the last three years, in an article giving in detail the methods he used to unearth the work of the German agents, quotes this message from his files, and explains how it was decoded. The message, in cipher, reads as follows:—

From—Berlin foreign office.

To—Botschaft, Washington:

669 (44-W)—Welt nineteen-fifteen warne 175 29 1 stop 175 1 2 stop durch 622 2 4 stop 19 7 18 stop LIX 11 3 4 5 6.

This cipher message came through from Nauen, Germany, to Sayville, Long Island, at 2 o'clock in the morning of April 29, 1915, and was caught by the operator at a wireless station maintained by the Providence Journal. It was especially interesting because it followed none of the codes which they had previously observed. It was evidently important, because four attempts were made to put it through before the German station succeeded in overcoming the unfavorable static conditions which prevailed that morning. Every attempt to decipher it failed, until somebody with a line on the internal activities of the German embassy remembered that during that morning Prince Hatzfeldt, of the embassy staff, had been looking for a New York World almanac. The first two words of the message "Welt (German for 'world') 1915" supplied the clue. Following the other numbers in the message as representing page, line, and word in the World Almanac for 1915, the Journal men decoded the message as follows:—

"Warn Lusitania passenger (s) through press not voyage across the Atlantic."

Two days later the German embassy printed the now historic advertisement in the New York papers warning travelers not to cross the Atlantic, and a week later, on May 7th, the Lusitania was sunk by a German submarine.

A dramatic touch of suggestion of death in the message lies in the fact that the word not in it is taken from the first sentence of an obituary of the late Joseph Pulitzer, former owner of the World, which publishes the "Almanac." And another grim bit of irony in it is that the last four words were taken from an advertisement of a well known marine motor headed "The Seal of Safety at Sea."

Two words of the message are spelled out in German. They are "warne," which in English is "warn," and "durch," which means "through." The word "Botschaft" is German for "Embassy."

Italy's Wireless Link With U. S. Established

DIRECT radio communication between an Italian government station in Rome and the Arlington station of the United States Navy here has been successfully established and daily use is being made for communications passing between the two governments.

The daily statements of the Italian war office will be received by radio from Rome and issued here for publication in the United States.

English Marconi Maintains Dividends

MARCONI Wireless Telegraph Co., Ltd. (of London) has declared a dividend of 7 per cent. on the preferred stock and a 5 per cent. Interim dividend on the Ordinary Stock. This is on account of the working for the last year.

Further dividends will probably be declared after the full results for the working of the year 1917 are ascertained.

These are the same dividends as were declared in 1917.

Numerous Short-Wave Sets in German Trenches

THE application of wireless telegraphy and telephony in the present war has undergone marked changes, owing to the unforeseen peculiarities of trench warfare. It was formerly assumed that wireless methods of communication would be unsuitable in such circumstances, owing to the ease with which such messages can be intercepted by the enemy. The tendency has, therefore, been to rely mainly on telephone connection, notwithstanding the ease with which this connection can be ruptured by bombardment. The destructive effect of modern artillery has made the ordinary method of laying wires along the surface of the ground or attaching them to trees of limited utility. Even buried wires are apt to be destroyed at an inconvenient moment by explosive shells, and therefore the depth at which such wires are buried has become continuously greater and the methods of protection more elaborate. The Germans have sought to get over this difficulty by laying a regular network of interconnected lines, according to L'Industrie Electrique, so that in the event of several being damaged there is still a path for the current. Even this precaution, however, may fail in a modern bombardment, and the Germans now appear to be relying to a much greater extent on wireless communication. The article gives particulars which are said to apply to the latest German practice, according to which it would appear that the antennas are mounted four meters above the surface, are about one hundred meters long, and emit waves of three hundred to six hundred meters. On the Eastern front about one hundred and ten wireless detachments are said to be employed.

International Strafing a Wireless Possibility

WHY did the German foreign minister, Kuehlmann, speak with annoyance of the Bolshevist use of the wireless in sowing broadcast the propaganda of Lenine and Trotzky?

On his return from Poland Ernest P. Bicknell of the American Red Cross described a peculiar international co-operation in the use of the wireless. Each nation, he said, takes its turn in sending messages, a certain period of the night being set aside for each. All the nations, whether holding with the entente allies or with the central powers, keep out of the air during the periods allotted to others. Mr. Bicknell declared that this was a portentous arrangement, though at the time he did not indicate in what way he thought it might demonstrate its great possibilities.

There seems to be little doubt that the Bolshevist government and perhaps other governments have been flashing to the German wireless stations facts, proposals and suggestions not at all acceptable to Potsdam.

Radio Science

A Novel Ammeter

A DISTINCT departure from the common methods of constructing current-indicating instruments is the vacuum ammeter shown in figure 1 developed by Marconi's Wireless Telegraphy Company, Ltd., of England. The instrument is particularly suitable for employment as a current gauge to indicate conditions of resonance in wireless telegraph circuits.

The meter possesses a notable degree of sensitiveness. In fact, when it is placed in the circuit of a wave-meter and the inductance coil of the wave-meter is held two feet from the primary winding of the oscillation transformer in a 1½ K.W. Marconi set, a practically full scale deflection is obtained. A direct advantage of this method in measuring the wave-length of a spark gap circuit is the elimination of the interference due to the noise of the spark which is especially troublesome when a crystalline rectifier and head telephone are used for determining the point of resonance.

The meter is now supplied as a low reading voltmeter or ammeter, or as a shunted ammeter having a normal resistance of about twelve ohms. A special high resistance type has resistance of thirty ohms. The gauges so far manufactured have maximum reading of .11 ampere and .035 ampere and 1.44 and 1.25 volts respectively. The lower limit of the scale in the first instrument is .02 ampere and in the second .007 ampere.

The particular instrument shown in the accompanying drawing is designed to read volts or amperes. The operation of the device follows: Under the tension of the spring, the pointer of the instrument rests in the zero position, but as the filament is heated by current passing through it, the filament elongates and the pointer takes up a new position. The angular displacement of the pointer is a measure of the current. To further protect the apparatus from damage, dust and corrosion, the air is exhausted from the bulb—the device is provided with an Edison screw socket so that the meter can be placed in the conventional type of lamp base.

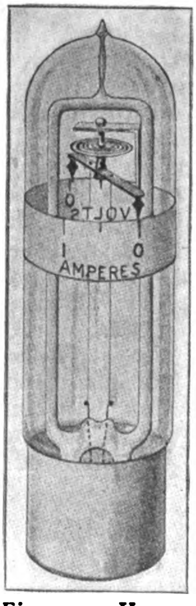


Figure 1—Vacuum ammeter

The meter will soon be available for ranges from 50 to 500 amperes and may be said to constitute a distinct and valuable addition to the line of radio frequency measuring instruments.

High Voltage Condenser for Radio Transmitters

THE most cumbersome part of a wireless telegraph transmitter is the high voltage condenser which not only takes up much space in the operating cabin, but, if of the oil type, is subject to break-down and is very inconvenient to handle.

William Dubilier of New York City has brought forward a type of high voltage condenser which is believed to have sufficient di-electric strength under the strain of the impressed voltage of the average wireless transmitter to absolutely prevent break-down. Another important feature of the condenser is that it is equally applicable to high and low voltages and therefore may be used in radio-frequency circuits of a wireless telegraph transmitter or for measurements in an experimental laboratory.

It will be noted from figures 2 and 3 that the complete condenser unit consists of six sections connected in series; each section consisting of a number of metallic plates separated by thin insulating material such as mica, the individual units comprising a plate condenser being insulated from one another by special insulating separators, as shown at 7 in figure 2. It is to be noted also that the con-

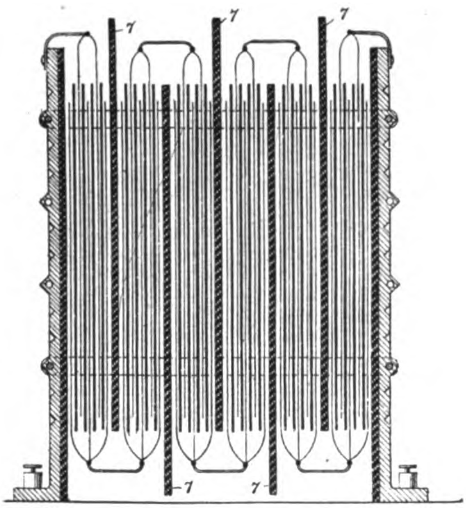


Figure 2

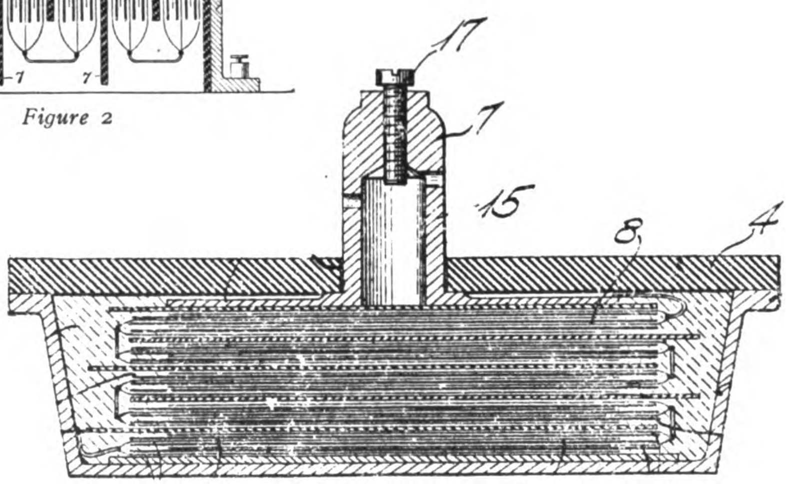


Figure 3

Figures 2 and 3—Two views of Dubilier high voltage condenser

ducting surface of the condensers are placed far enough from the top to prevent the current discharging over the ends.

The inventor points out that the leakage of energy due to brush discharge at high potentials constitutes one of the greatest losses in the ordinary high voltage condenser, and to overcome this, he mounts several condensers in a single

unit; for example, in one type ten sections are connected in series and if the outer terminals are subjected to a potential of 15,000 volts, the potential difference across each section is only 1,500 volts and, as is well known, the brush discharge at this potential is practically nil.

Another loss of energy in the ordinary high voltage condenser is that of leakage due to dampness or moisture accumulating on the surface. The inventor overcomes this by sealing the entire condenser unit in a container and filling it with a melted insulating compound. While the compound is still hot, the condenser tank is connected to a vacuum pump and all air bubbles withdrawn. This may be said to constitute an important feature of construction because in this way air pockets are entirely eliminated and the break-down which usually occurs at these places is prevented.

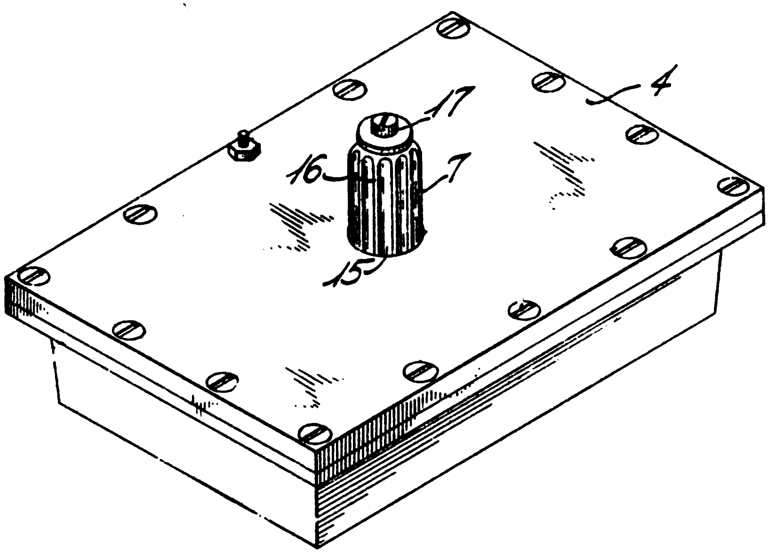


Figure 4—Single unit condenser for high potentials

Although the capacity of several condenser units connected in series in this way is considerably less than that of a single condenser, the required capacity for a given radio transmitter can be obtained by connecting several of such condensers in parallel. Although this condenser requires more plates than the usual type for high voltage purposes, the heat losses are much reduced and the conduction is better, because the power taken by each plate is relatively much less. Since the losses due to brush discharge in any condenser will be proportional to the square of the voltage, it is easily seen that the losses in this condenser will be but a very small percentage of what they would be if the entire line potential were applied to any two adjacent plates. Insulating or di-electric materials other than mica may be employed, but they must be homogeneous and able to withstand the tension and heat which attend high potential currents.

A condenser built in this manner mounted in a single unit is shown in the perspective in figure 4. It is admirably adapted for high potentials with no danger of injury and eliminates the heavy losses heretofore experienced. At the same time, owing to its compactness (due to the thinness of the di-electric) its adaptability for low potentials is maintained to the fullest extent.

A Receiver for Undamped Oscillations

ROY A. WEAGANT, chief engineer of the American Marconi Company, is credited with the novel system for the reception of damped and undamped oscillations shown in the accompanying diagram, figure 5, in which the antenna circuit and the receiving apparatus are represented by the usual elements. The secondary system comprises the condenser C-5, a loading coil 4, and the secondary

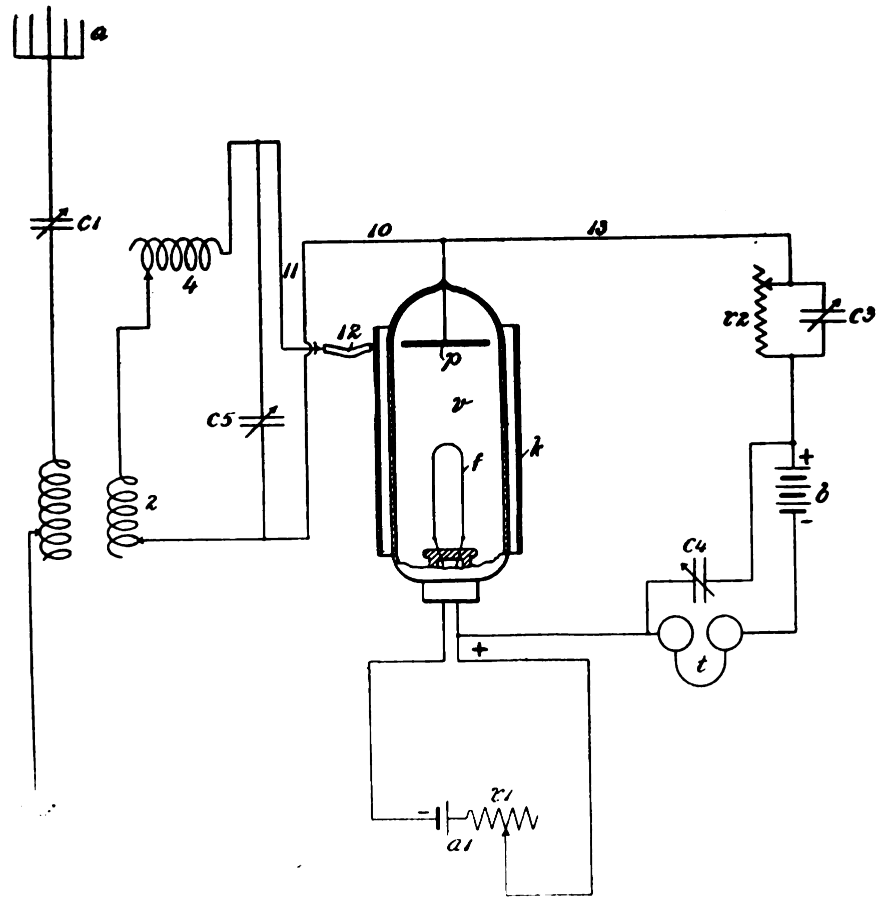


Figure 5—Valve receiver circuit for reception of damped and undamped oscillations

inductance 2. The oscillation valve comprises the plate P, the metallic envelope K, and the filament F. Another feature of this circuit is the plate circuit resistance, R-2, and the shunt condenser, C-3.

The inventor states that by means of this combination of capacity and shunt resistance, he is enabled to adjust the voltage of the plate battery to a value higher than would be possible without its use. A very critical adjustment of the valve is thus obtained, so that the effect of very minute disturbances impressed thereon causes a much greater flow of current through the head telephones. In other words, amplification is secured. It is to be noted from the diagram, that the secondary terminals of the receiving tuner are connected to the metallic envelope K and to the plate P. Correct adjustment of plate battery B, the temperature of

the filament through rheostat C-1, and the capacity of condensers C-3, C-4, and C-5 will cause the valve to oscillate at an audio or radio frequency. Thus, it may be employed as a receiver of undamped oscillations for the production of beat currents. The resistance R-2 in the circuit shown is variable, and must be of the order of the normal resistance of the circuit between the electrodes F and P.

Open Circuit Oscillators In Receiving Tuners

A RECEIVING system employing so-called open circuit coils has recently been described among the patent issues. One method of connection is shown in figure 6, where the antenna circuit is represented at A, 4, G, the open coils at 5 and 6, and the crystal rectifier at D shunted by the head telephone T. The coils 5 and 6 are wound so that the potentials of their extreme ends will be opposite, as shown.

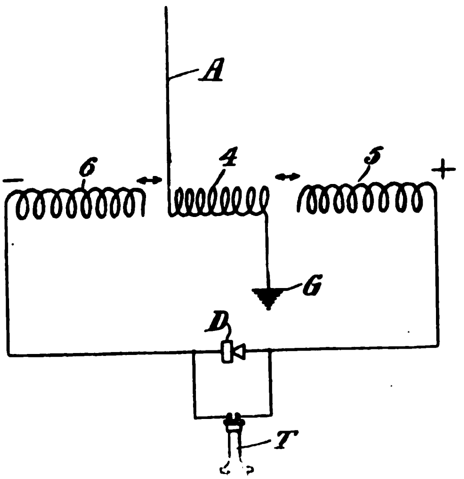


Figure 6—One method of connecting open circuit coils in a receiving system

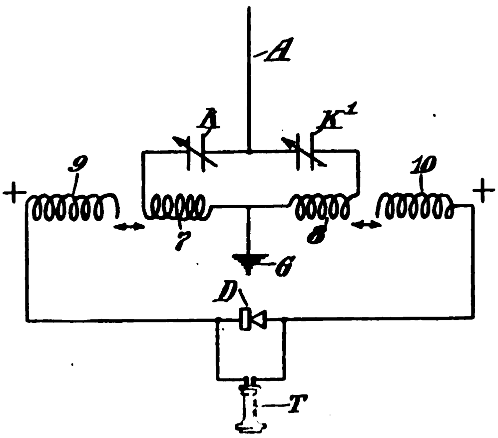


Figure 7—Another method constituting the well-known interference preventer

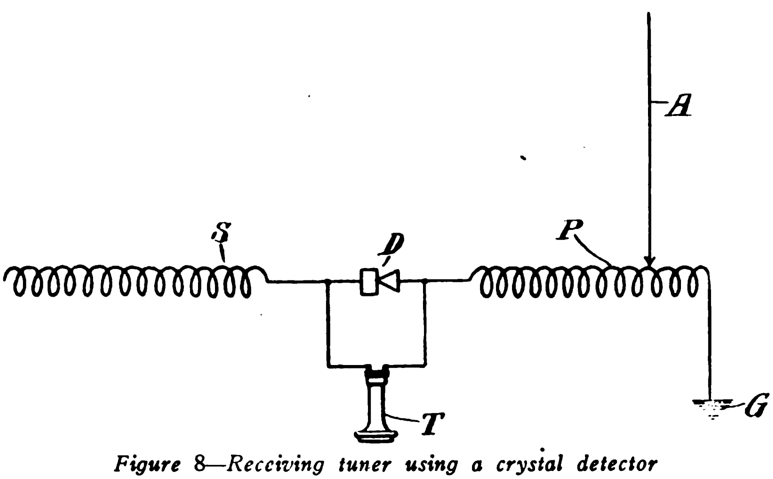


Figure 8—Receiving tuner using a crystal detector

In the practical operation of this system, the operator adjusts the coupling between the antenna coil 4 and the detector coils 5 and 6. Obviously, coils 5 and 6 oscillate by virtue of the distributed capacity between turns.

In the diagram of figure 7, coils 5 and 6 of the first diagram are represented by 9 and 10, being connected to primaries 7 and 8, respectively. This arrangement constitutes the circuits of the well-known interference preventer. Thus. one side of the system may be detuned and signals received on the opposite side, but waves of high decrement are assumed to effect both sides equally.

It is to be noted in the diagram of figure 6, that coils 9 and 10 are connected in opposition.

Another system of reception is shown in figure 8. Here, a long coil P is attached to the antenna connection A and the earth connection G. A crystal detector D is connected between coils P and S which have similar dimensions. Radio frequency oscillations induced in the receiving aerial A cause the circuit G, P, S, to oscillate at a similar frequency, the currents being rectified by the crystal D.

The use of open circuit coils in radio receivers has been previously described in this department.

An Inclosed Arc of Novel Characteristics

AN inclosed arc device possessing an unusually low voltage drop, as shown in figure 9, is the invention of John Clough. The device consists of a low expansion glass envelope (1), such as a sodium-magnesium, boro-silicate glass; the cath-

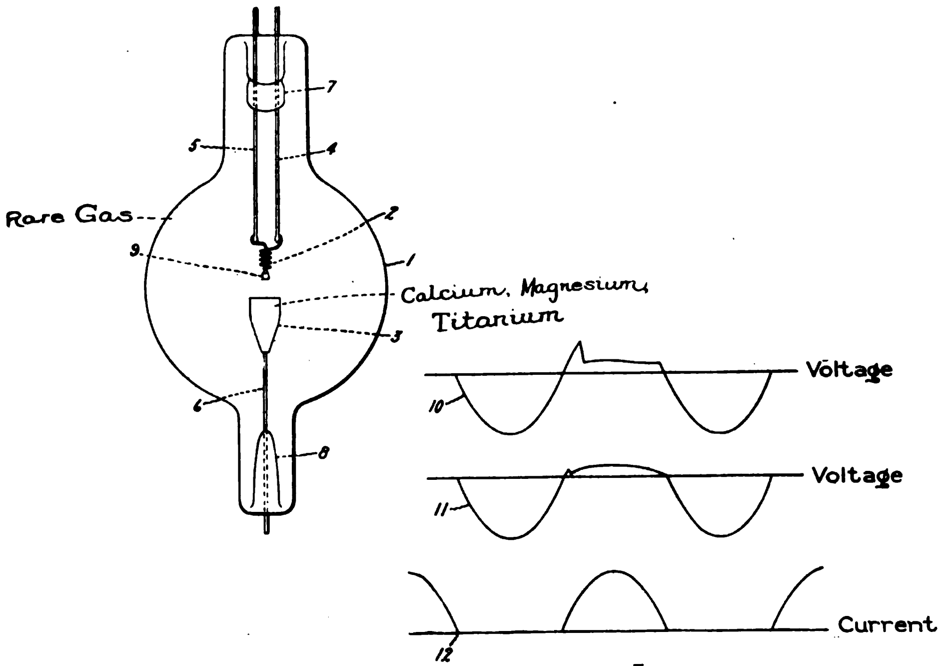


Figure 9—Inclosed arc possessing unusual low voltage drop

ode (2), consists of a highly refractory material such as tungsten, tantulum or carbon. The anode (3) is made up of metallic calcium, magnesium, titanium or other metal highly reactive chemically to gases other than the inert so-called rare or monatomic gases. The filament supply wires are designated at (4) and (5), the anode conductor at (6) which are sealed in the stems. The cathode is preferably provided with a tip (9) having a somewhat greater diameter than the adjoining sections.

In former arcs of this type, the anode was made of refractory metal such as tungsten, carbon, or tantulum; but it has been discovered that if it is constituted in part or entirely of a highly chemically reactive metal such, for example, as cal-

cium, magnesium or titanium, the gaseous atmosphere surrounding the arc consists of a monatomic gas such as argon, neon, xenon, krypton, or helium. A voltage drop in the arc of a hitherto unattainably low value is obtained. When arc devices such as this are operated in series with an external resistance or load, part of the impressed voltage is consumed in the arc itself. This ordinarily is termed the arc drop, the value of which is approximately twenty volts when the anode consists of tungsten. But in an arc constructed after Clough's design, wherein the anode consists wholly or in part of calcium or highly chemically reactive material, the arc voltage may be as low as 4 to 5 volts. In fact, the inventor declares that when argon was introduced into an arc constructed in accordance with his specifications, an 8 ampere arc was produced with the cathode at bright incandescence at a voltage drop of 10.4 volts. After three hours with the calcium anode the voltage drop had decreased to 7.8 volts. With the twenty ampere arc an initial arc drop of 6.9 volts was observed, which in three hours of operation had decreased to 4.5 volts. In a neon atmosphere of about 1/4 atmospheric pressure purified by the usual chemical methods, a 10-ampere arc was found initially to have a voltage drop of about 5.8 volts. The chemical effect of the calcium anode reduced the voltage drop to about 12.5 volts in forty minutes.

A remarkably low voltage is required to start the arc of figure 9. A 15-ampere arc, for example, may be formed with a potential as low as 14 volts, provided the temperature of the cathode is 2,500 degrees Centigrade.

In the former type of arc, the voltage must rise to value about double that required to maintain the arc, before it will start and current be transmitted, but as soon as an arc is formed the voltage quickly drops to a lower value and then remains nearly steady until near the end of the half wave when the arc again goes out as the voltage approaches a zero value. But in the improved device, the voltage at the beginning of the wave during which an arc is operating does not rise to a value higher than the operating voltage of the arc. This the inventor believes to be strictly new to the art.

Progress In Wave-Changing Devices

In the early days of radio development in the United States, it was customary to tune a ship's transmitter to the natural wave-length of the antenna regardless of its length; also, the majority of transmitters were very closely coupled, causing the antenna to radiate two waves. While this was not a desirable condition in the majority of cases, in certain instances it was of real benefit, because if the operator receiving experienced interference on one of the waves radiated by a given transmitter he could retune his equipment to the other wave and thereby receive signals. It is interesting to note that although considerable interference was caused by this double wave emission, it was often found that the decrement of the longer wave was far within the limit of the present-day Government restrictions.

At the time when the United States Government signed the articles of the London Convention, all ships were retuned and adjusted to the standard wave-lengths of 300 and 600 meters. It was somewhat difficult in some installations to reduce the natural wave-length of the antenna by means of the short wave condenser to the smaller value (300 meters) and in extreme cases it became necessary to erect a separate aerial for radiating energy at this wave-length.

The modern transmitters of the Marconi Wireless Telegraph Company of America are designed to radiate three standard waves of 300, 450 and 600 meters. This apparatus is constructed so that these wave-lengths can be instantly changed by merely throwing a switch. The convenience of an apparatus of this type cannot be over-estimated. A great deal of interference heretofore experienced has now been done away with.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

TENTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

The Camp Telephone

This telephone, which supersedes the field telephone, was developed by the Signal Corps for use in connection with camp telephone systems and small arms target range system, and may be installed in tents and structures, or considered a portable instrument for use in the field for testing lines or other purposes.

It is of local battery type. The battery employed is one unit of tungsten type A. Figures 1 and 2 illustrate this telephone, it being shown dismantled in figure 2 to facilitate identification of parts in connection with the preparation of requisitions for renewals.

The first lot of these instruments was equipped with 2-bar magnetos and due to its limitations the instrument could not be used for long-distance work. The new model of this instrument will be equipped with a 3-bar magneto, employing a special high grade steel for permanent magnets, and while in other features there may be a slight deviation from the following description it is believed that figures 1 and 2 can be used in preparing requisitions, it being merely necessary to state "For Camp Telephone, 3-bar magneto type."

The instrument is made as compact as practicable and is contained in an oak case 4¼ by 7 by 10 inches high. The top consists of a metal hinged cover with circuit diagram on inside, held rigid when closed by a spring snap which can be released by depressing a button. The bottom of case is covered by a flanged piece

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

of metal, the flange projecting approximately one-half inch up sides of case. Through one side of the case are six three-eighth inch holes which are covered on the outside by a close mesh metal screen held in place by a metal frame. These apertures allow the ringer to be distinctly heard. The case is equipped with a substantial, adjustable carrying strap, each end of which is fastened to case by means of hinged metal rings.

A small 2-bar magneto generator, small ringer, induction coil, aluminum chamber for the single unit of tungsten type A dry battery, hard rubber block upon which are mounted line binding posts, plug connections for the hand-set used with the instrument, hook switch and hook operating it and auxiliary battery binding posts are all mounted on a common base which may be readily removed

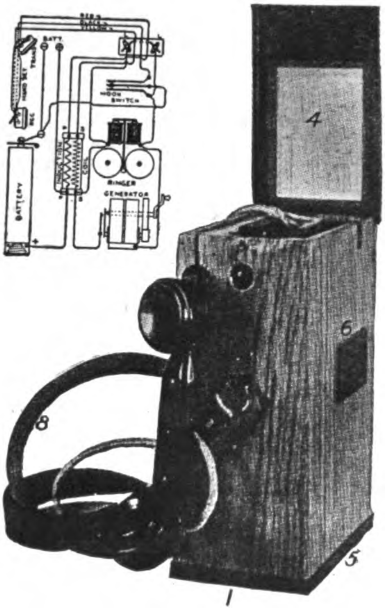


FIG. 1.—THE CAMP TELEPHONE AND ITS CIRCUITS

Key to reference numbers:—1, case; 2, hinged cover; 3, circuit diagram frame; 4, circuit diagram; 5, metal base for case; 6, wire netting frame; 7, wire netting; 8, carrying strap; 9, fitting and ring for carrying strap

from case after removing magneto generator crank, metal housing for it and three screws which extend through the case.

The instrument may be operated with cover closed, which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the 3-conductor cord to receiver and transmitter, the two latter being mounted in the form of a unit, termed a hand-set. This hand-set consists of a transmitter and receiver mounted on a metal piece and is so designed that when the transmitter is normally placed to the mouth, the receiver is automatically adjusted to the ear.

The hook of the hook switch is so designed that it protrudes through case. When it is desired to transport the instrument or to remove the base upon which is mounted all the parts of the instrument, it is merely necessary to depress the hook and push it toward the base. By this arrangement the hook is not only held in the down position, thereby opening the battery circuit, but it is also protected.

The aluminum chamber for housing the single unit of tungsten type A battery is equipped with a spring catch so located that when upper hinged piece is depressed to proper postion the battery compresses a helical spring, thereby insuring continual contact. The base is equipped with two screw binding posts which may be used to connect leads to an outside battery in the event of there being no tungsten type A batteries available.

An aluminum frame, which is supported on the base previously mentioned,

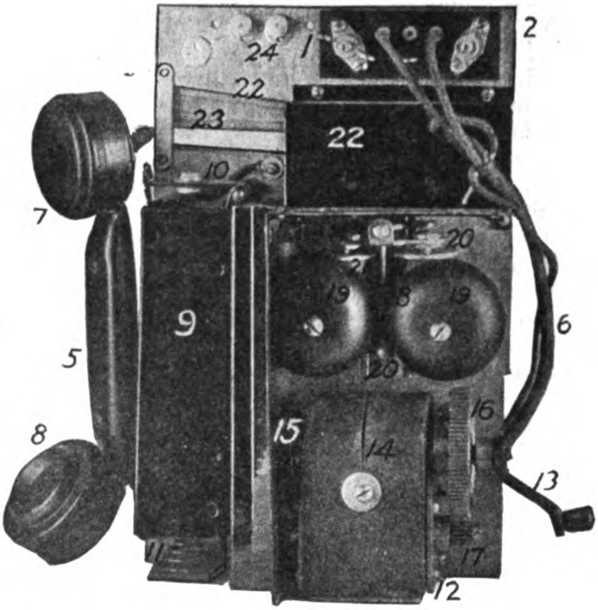


FIG. 2.—CAMP TELEPHONE, DISMANTLED

Key to reference numbers:—1, *base;* 2 *connecting block with binding posts;* 3, *binding post;* 4, *socket for hand-set cord;* 5, *hand-set;* 6, *hand-set cord;* 7, *hand-set receiver;* 8, *hand-set transmitter;* 9, *battery case;* 10, *battery-spring catch;* 11, *battery spring and support;* 12, *magneto;* 13, *magneto crank handle;* 14, *permanent magnet for magneto;* 15, *contact spring;* 16, *magneto gear;* 17, *magneto pinion;* 18, *ringer;* 19, *gong;* 20, *hammer and armature for ringer;* 21, *ringer coils;* 22, *case for hook switch;* 23, *switch hook;* 24, *binding posts for external battery*

forms a compartment for the hand-set when instrument is being transported. When the instrument is installed for a temporary period, unless in actual operation, the proper place for the hand-set is hanging on the hook of hook switch, there being a ring on the hand-set for this purpose.

A small screw driver which will fit practically all screws used in the construction of the instrument is supported by the metal frame and is furnished with each instrument. The instrument complete weighs approximately 11 pounds.

The Service Buzzer

The buzzer is strictly a portable instrument and is issued to troops in the field for use in connection with all kinds of communication. It may be used as a telephone or for sending Morse or Continental Code signals, and for that reason it is specially adapted for field use.

When it becomes impracticable to transmit messages telephonically, due to the line becoming impaired or for other reasons, the usual telegraphic signals can be transmitted and are received in distance telephone receivers in the form of a

high-pitched hum, somewhat similar to radiotelegraphic signals. These signals have been exchanged between two of these instruments after the wire line had been severed, both the ends, however, being slightly grounded.

The service buzzer, which is the latest approved instrument of this type of apparatus, replaces the field buzzer, the cavalry buzzer and the field artillery telephone and hereafter is the standard issue.

A circuit of high E. M. F. is obtained by means of two coils of wire wound on a soft iron core in connection with the telephone. This method may be termed mutual induction and is employed in the service buzzer. A high E. M. F. can be obtained by means of one coil of wire wound on a soft iron core, the latter method being termed self-induction. In order that operation of the service buzzer may be clearly understood, the theory of the field buzzer will first be explained.

The principle upon which the original *field buzzer* operates depends upon the effects of self-induction, i. e., the comparatively high self-induced voltage developed at the terminals of an electromagnet (coil with iron core) when the current through the circuit is suddenly interrupted. The interruptions are automatically produced by a circuit breaker, which is described later. During the interval of time required for the current to reach its maximum value, the field of force expands in direct proportion to the current strength until it also reaches maximum value. The current strength being kept constant, the magnetic field is of constant value. Any variation in current strength produces a corresponding variation in the strength of the magnetic field; therefore, when the circuit is broken and the current rapidly falls to zero the field of force also collapses and disappears. The energy furnished by the current and stored up in the magnetic field is thus returned to the circuit and tends to sustain the original current, as is noticed by a bright spark appearing at the point of break.

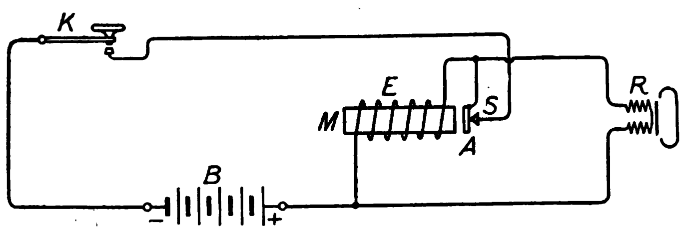


Figure 3—Simplified circuit of field buzzer

On "make," then, the whirls spring out from and cut the wire, inducing therein a current opposed in direction to inducing current. On "break" the whirls collapse, again cutting the wire and inducing therein a current having same direction as inducing current. The phenomena resulting from such cutting of a wire by magnetic lines of force is called self-induction.

When the circuit contains a coil, the effects of self-induction are much greater. If the coil contains an iron core the effects of self-induction are still more pronounced.

To make clear the action of the buzzer, let us consider the diagram, figure 3:

B is a battery of five dry cells; *K* is a key for making and breaking the circuit; *E* an electromagnet; *R* a telephone receiver.

When the key is closed there is a rush of current which reaches its maximum strength almost instantly. Simultaneously there is built up a magnetic field of force around the electromagnet. Now, if the key be opened, a pronounced click, of momentary duration, is heard in the receiver, which is caused by a self-induced current of high E. M. F. produced by the collapse of the magnetic field around the coil. This induced current would spark across the break at the key if there were not an alternate complete circuit through the receiver.

The more rapidly the circuit is made and broken by closing and opening the key, the greater the rapidity with which clicks in telephone follow one another,

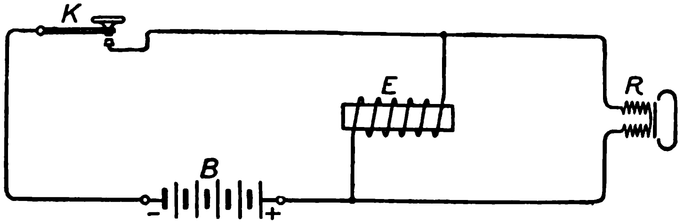


Figure 4—Field buzzer simplified circuit with interrupter

until, if the interruptions recur sufficiently often, the sounds in the receiver appear to be almost continuous.

If we introduce an automatic interrupter into the circuit (fig. 4), a loud buzzing sound is heard in the receiver whenever the key is closed, and the dot and dash of the Morse alphabet are thereby produced by making short and long contacts with key.

The action of the interrupter or circuit breaker is as follows:

When the circuit is made by closing the key *K*, the current flows through coils of the electromagnet *E*, magnetizing the iron core *M*, which, in turn, attracts armature *A*. As soon as the armature is withdrawn from contact *S* the circuit is broken; as a result, the core becomes demagnetized and armature *A* springs back against *S*, thus again closing the circuit. The action continues so long as key *K* is kept closed.

If instead of the interrupter we substitute therefor a transmitter (fig. 5), then when the key is closed current flows from + side of the battery through the coil to the lower disk (stationary) of transmitter, through loosely packed carbon granules to upper disk (movable), which is attached to the diaphragm, to key, to — side of battery.

Except when this circuit is first made, there is no evidence of self-induction in the circuit until the transmitter is spoken into, then the sound waves of the voice striking the diaphragm cause it to vibrate. The carbon granules between the carbon disks are thus subjected to varying pressure; this causes a variable resistance in the circuit, and the resulting current is a pulsating one (uniform in direction, but varying in strength). The effect of the varying current passing through the circuit is to increase and decrease the field of force built up around the wire. This changing field of force in turn produces the effects of self-induction, and these effects are particularly noticeable in coil *E*.

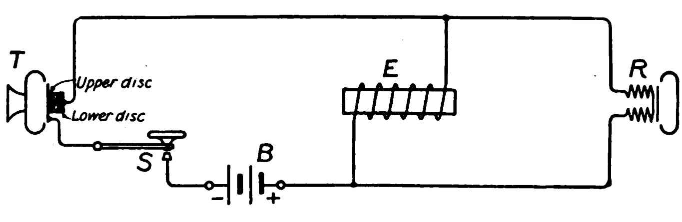


Figure 5—Simplified circuit of field buzzer with transmitter

The inductive property of the coil is thus employed to augment the comparatively weak primary current to one of high E. M. F., which intensifies the vibration of the receiver diaphragm, these vibrations being received by the ear as articulate speech.

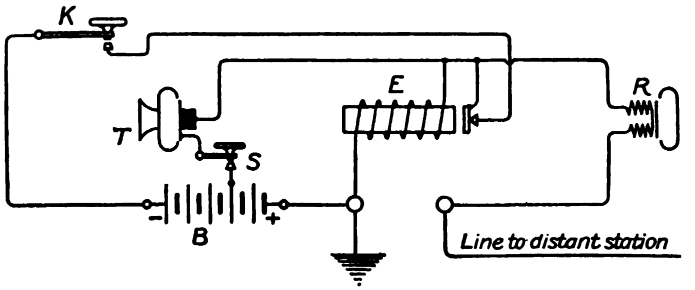


Figure 6—Simplified circuit of field buzzer with transmitter and interrupter

The sounds thus produced are not as loud as those produced by the interrupter, even though the same number of cells are used, for the reason that in the latter case the current is completely interrupted (circuit broken), whereas, in the case of the talking circuit, current is always flowing but is varied in strength; therefore the resulting field of force never reduces to zero, the cutting of the wire is consequently less, and the effects of self-induction are diminished.

If we now combine the two circuits described in one diagram we have the simplified buzzer diagram which is shown in fig. 6.

An examination of this figure shows that the only change made is the introduction of two terminal binding posts, one of which is connected to the line, the other to the ground. If a similar instrument is connected at the distant stations, the currents traversing the home receiver also pass through the distant receiver.

The utilization of existing telegraph lines as a part of or the whole of a circuit for buzzer and telephone working, at the same time not interfering with the use of a wire for Morse working, may be effected by using condensers interposed between the line and the buzzer. See fig. 7.

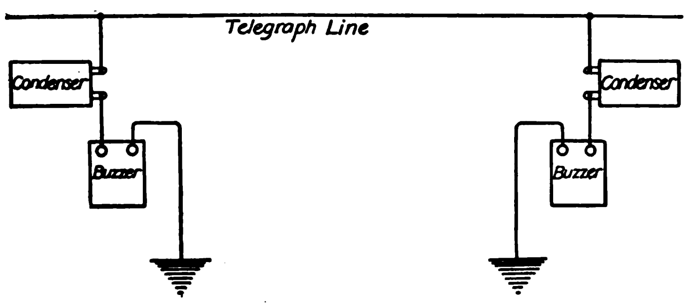


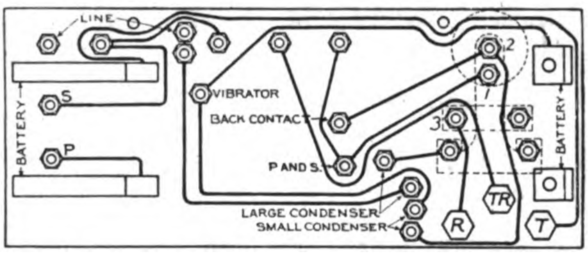
Figure 7—Buzzers connected to a telegraph line

The pulsations of the ordinary Morse sending are comparatively slow. The condensers, therefore, act as a very large resistance, and no appreciable effect will be noticed in the telegraph line.

The very rapid pulsations produced by the buzzer or transmitter, however, will permit of transmission from one buzzer to the other with little diminution of sound.

Figure 8 shows the circuits of the service buzzer. It will be noted that with the field buzzer if a line of low insulation resistance is utilized a heavy drain on the battery will ensue, due to the battery being connected to the line, while with the service buzzer under like conditions a heavy drain will not exist, due to the battery being connected in a local circuit which does not physically connect with the line. It will also be noted that a condenser which can be cut out by means of a short-circuiting switch is contained in the instrument and connected in series with the

line. This condenser is for use when it is desired to use an existing telegraph line. (See fig. 7.) Two units of tungsten type A dry battery are used with the service buzzer for furnishing the necessary primary current, both being in circuit when sending telegraphic signals, and one only being in transmitter circuit for telephone communication.



BOTTOM VIEW OF BACKBOARD SHOWING WIRING

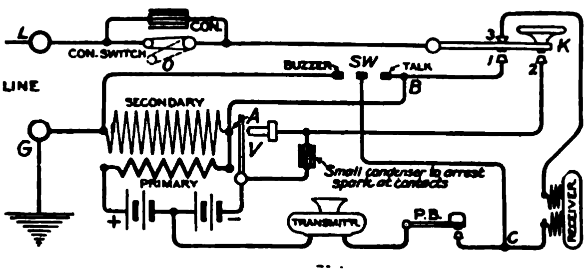


Figure 8—Service buzzer circuits

The circuits of the service buzzer may be classed as follows:

Primary sending circuit—telegraph.
Secondary sending circuit—telegraph.
Receiving circuit—telegraph.
Primary sending circuit—telephone.
Secondary sending circuit—telephone.
Receiving circuit—telephone.

These circuits may be traced as follows, reference being made to figure 8:

Primary Sending Circuit—Telegraph

S. P. D. T. knife switch marked *"Sw"* must be closed on side marked "buzzer." Upon depressing key *K,* circuit is as follows: Positive end of battery, through primary induction coil, to *A* to *B,* contact 1 of key, lever of key, contact 2, vibrator, to negative end of battery.

Secondary Sending Circuit—Telegraph

S. P. D. T. knife switch marked *"Sw"* is closed on side marked "buzzer." An A. C. current of high E. M. F. is induced in the secondary winding of the induction coil by interrupted current in the primary and its path is as follows: *G,* earth or one side of line (if metallic circuit is used); "receiving circuit, telegraph" of distant buzzer, other side of line, *L,* contact 1 of key (key is depressed), *B, A,* other side of secondary winding of induction coil.

Receiving Circuit—Telegraph

S. P. D. T. knife switch marked *"Sw"* is closed on side marked "buzzer." A. C. current of high E. M. F. reaches *L* from distant instrument by one side of

line, contact 3 of key (key raised), reciver, *C*, switch marked *"Sw"* G, other side of line to distant instrument.

Primary Sending Circuit—Telephone

S. P. D. T. knife switch marked *"Sw"* is closed on side marked "talk"; from positive end of battery through primary winding of induction coil, to *A*, to *B*, through blade of switch marked *"Sw"* to *C*, through push-button switch marked *"PB,"* through transmitter to negative side of one unit of the tungsten type A battery.

Secondary Sending Circuit—Telephone

S. P. D. T. knife switch marked *"Sw"* is closed on side marked "talk." When sound waves fall upon the diaphragm of the transmitter, an alternating current of high E. M. F. is induced in secondary winding of the induction coil. Starting with secondary of induction coil, to *G*, to earth or one side of line (if metallic circuit be used), through "receiving-circuit-telephone" of distant instrument, returning on other side of line, to *L*, through contact 3 of key marked *"K"* (key raised), to receiver, to *C*, to switch marked *"Sw,"* through blade of this switch to *B*, to *A*, to other side of secondary winding of induction coil.

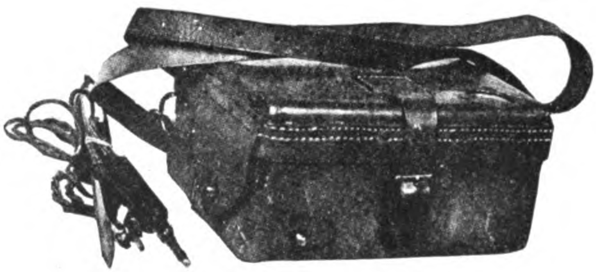


Figure 9—Service buzzer

Receiving Circuit—Telephone

S. P. D. T. knife switch marked *"Sw"* is closed on side marked "talk." An alternating current of high E. M. F. induced in the secondary winding of induction coil in distant instrument reaches the buzzer over outside line, to *L*, thence to contact 3 of key marked *"K,"* to receiver, to *C*, to switch marked *"Sw,"* through blade of this switch to *B*, to *A*, through secondary winding of induction coil to *G*, to earth or line (if metallic circuit be used), to distant buzzer.

When an existing telegraph line is utilized, the switch marked *"con sw"* should be thrown to the "O" position in order that the condenser *"Con"* will be placed in the circuit.

The service buzzer is shown in accompanying figures 9 and 10, it being shown dismantled in figure 10 to facilitate preparation of requisitions for renewal parts.

The instrument is contained in an aluminum case fitted with a hinged cover, both of which are covered externally with a russet-colored, smooth-finished leather which is neatly sewed and riveted in place. The overall outside dimensions of the case are approximately 3¼ by 5¼ by 7½ inches. The two units of tungsten type A battery are contained in a chamber located in the bottom and are accessible without opening the main cover, there being an additional small hinged cover in one end of case which is fastened securely, when closed, by a substantial spring clip, and by a flap of leather.

The instrument may be operated with both covers closed, which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the cords to the receiver and transmitter, and in main cover, directly over the sending key, is a round aperture which is made moisture-proof by means of a covering of extremely flexible pigskin. The sending key can be readily operated through this flexible pigskin.

The sending key, induction coil, condensers, plug jack, transfer switch, vibra-

tor, and binding posts for transmitter and receiver cords are mounted upon a common base of hard rubber. Wiring to the component parts is routed in the under side of this base, which is mounted in the front of the case above the battery chamber previously mentioned. In the rear of the instrument is a compartment of leather for containing the transmitter, receiver, and cord for connecting them. At one end of this chamber, neatly mounted on a hard rubber strip, is a socket wrench for adjusting the nuts which secure the transmitter and receiver terminals, also two screw drivers—one large and one small—which are so constructed that the shanks may be inserted in the end of socket wrench, thereby using the socket wrench as a handle.

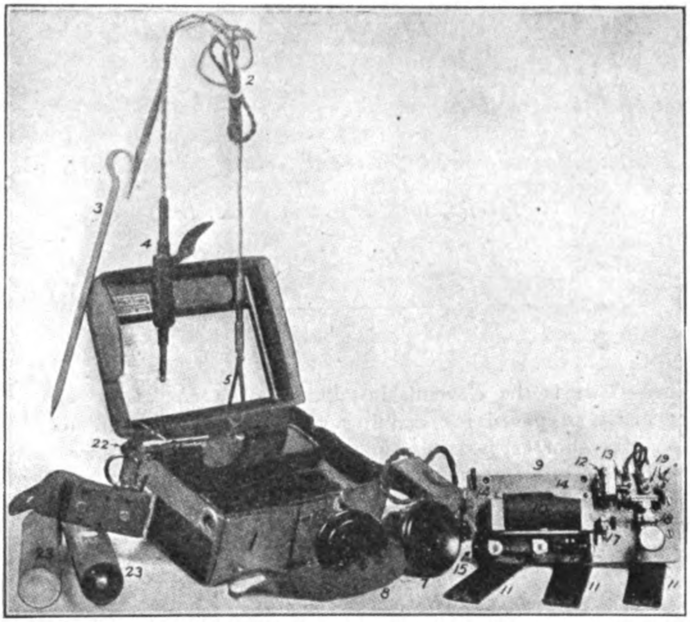


FIG. 10.—SERVICE BUZZER, DISMANTLED

Key to reference numbers:—1, case; 2, main cord with terminals; 3, ground rod, type D; 4, plug; 5, connector, type A; 6, transmitter; 7, receiver; 8, head band; 9, base; 10, induction coil; 11, condensers; 12, condenser connecting blocks; 13, short-circuit switch; 14, holding clip; 15, jack plug; 16, transfer switch; 17, vibrator; 18, sending key; 19, binding post; 20, large screw driver; 21, small screw driver; 22, handle for screw drivers and wrench; 23, tungsten battery, type A

Invariably there is furnished with this instrument a two-conductor cord, approximately 5 feet long, one end of which is equipped with a substantial plug similar to those used in connection with telephone switchboards. At other end one of the conductors is equipped with a Williams test clamp for connection to line, the other conductor being equipped with a Signal Corps type D ground rod. The Williams test clamp is so constructed that to attach it to the line, it is merely necessary to compress the two principal parts, releasing them when the line has been inserted in space provided. One side of this clamp is equipped with an 11-point stud securely threaded to test clamp. These points make excellent contact on line, regardless of whether the line be insulated or not. By this means a quick connection can be made to buzzer wire or field wire which is insulated, and when the clamp is removed the abrasion to insulation is negligible. There is an opening in the case of the buzzer through which the plug is inserted when connection is desired, and when plug is so inserted it makes a positive connection by means of a substantial jack mounted on the base as previously indicated.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XI

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

Editor's Note—This is the eleventh installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of The Wireless Age. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

SPARK DISCHARGERS

(1) The efficiency of a radio transmitter for the production of damped oscillations depends largely upon the design of the spark discharger. Hence, it is important that it be constructed in accordance with certain fundamental principles.

(2) The functions of the spark gap are:

(1) **to keep the closed oscillation circuit idle until the condenser is fully charged;**

(2) **to discharge the energy stored up in the condenser in the form of radio frequency oscillations;**

(3) **to quench the oscillations in the closed oscillation circuit or, in other words, to restore the gap to its non-conducting state after the energy of the condenser has been most effectively transferred to the aerial circuit.**

(3) Previous to the discharge of the condenser, the resistance of the spark gap is infinite, but as the air surrounding the electrodes is burnt by the spark discharge, the resistance falls rapidly. The charge in the condenser, however, is soon emptied and as the oscillating current decreases, the resistance increases until the voltage of the primary circuit becomes so low that the spark can no longer bridge the gap. The primary oscillations then cease.

(4) It is due to the **lag in the cooling of the gap electrodes and the dissipation of the burnt gases** that the current oscillates in the primary circuit. If there were no lag in the cooling, i.e., if the burnt gases surrounding the electrodes were immediately removed the non-conducting state of the gap would be restored after the first half cycle of the radio frequency current. The lag in cooling, however, permits the current to oscillate through a number of cycles before the oscillations cease.

(5) The most efficient spark gap is one designed to remain conductive until the energy of the condenser circuit is transferred to the aerial wires. When the energy of the closed circuit has been transferred to the antenna, the non-conducting state of the gap should be restored immediately.

(6) Retransference of energy from the aerial wires to the closed circuit is thus prevented. Greater efficiency results thereby, because the antenna oscillates at its own natural frequency and damping.

(7) If the non-conducting state of the gap is not restored at this moment, there will be an interchange of energy between the open and closed oscillation circuits, which causes the antenna to oscillate at two frequencies resulting in **the radiation of two waves.** Double wave emission obviously causes unnecessary interference.

(8) Speaking generally, a spark gap designed to transfer the energy from the spark gap circuit to the antenna circuit in one or two cycles and to become non-conductive at such a time that no retransference of energy from the antenna circuit can take place is said to **quench the primary oscillations.** Such a transmitter will radiate a single wave.

(9) Quenching of the primary oscillations may be obtained in several ways:

(a) **by breaking up the spark discharge into several short gaps no more than .01 of an inch in length;**

(b) **by cooling the gap by rotating the electrodes;**

(c) **by applying a blast of air directly to the spark discharge;**

(d) **by correct design of the generator and transformer or both to prevent arcing at the spark gap;**

(e) **by reduction of the coupling at the oscillation transformer.**

In some systems all of these means are employed simultaneously and in others only in part.

(10) Correct design of the alternator and transformer assists greatly the quenching of the primary oscillations. It must be remembered that the transformer secondary is practically on short circuit when the spark discharges across the gap. Hence, unless the source of energy possesses a certain amount of magnetic leakage either in the dynamo, in the transformer, or in the primary or secondary reactance coils, or the possibility of short circuit is prevented by the insertion of resistance, the quenching will not be reliable. In this case, the spark discharge will be followed by a certain amount of transformer arc which will prevent quenching unless very loose couplings are employed between the primary and secondary of the oscillation transformer.

(11) The **application of an air blast, careful adjustment of the length of the gap,** and **reduction of the coupling** will quench the primary oscillations and give **single wave emission** with any type of gap. But with gaps designed especially to obtain these results, quenching is secured with very close couplings at the oscillation transformer and increased efficiency is thus obtained.

(12) Quenching of the primary oscillations is secured with the following types of spark gaps:

(a) The non-synchronous rotary spark discharger.

(b) The synchronous rotary discharger.

(c) The multi-plate or series discharger.

(13) In addition to quenching, the non-synchronous rotary gap affords a spark note of musical pitch from a low frequency charging current such as 60 cycles.

(14) In addition to providing a uniform spark discharge the **synchronous spark gap** discharges the condenser once for each alternation of the charging current, thus giving a more uniform note than the non-synchronous gap. The **multi-plate gap** gives synchronous discharges if the alternating voltage is properly adjusted, and very effective quenching even when the open and closed oscillation circuits are closely coupled. The plain or **simple spark discharger** comprising two simple electrodes is now employed only in event of emergency. Quenching effects can be obtained from the plain discharger by applying an air blast at a great velocity to the electrodes.

SPARK NOTE ADJUSTMENT

(1) The next important consideration in respect to spark gaps, particularly from the viewpoint of commercial operation, is the adjustment of the **spark pitch or note.** In brief, the pitch of the spark is reproduced in the telephone at the receiving station. Thus, 1,000 sparks at the transmitter will impulse the diaphragm of the telephone receiver 1,000 times.

(2) There are two principal reasons for employing high pitched spark notes:

(a) the telephone diaphragm gives greater response when impulsed at rates from 700 to 1,000 times per second;

(b) a high pitched spark note enables the receiving operator to distinguish radio signals from the crashing sounds of atmospheric electricity.

With different types of dischargers, clearness of tone is secured in different ways. The best tones are secured from apparatus harmoniously designed from the generator to the spark gap. Methods of spark gap adjustment will be presented in the explanation of the drawings to follow.

OSCILLATION TRANSFORMERS

(1) The transformers employed to transfer energy at **radio frequencies** to the antenna circuit offer a striking contrast to those used for transformation at lower frequencies. The former types generally consist of a few turns of copper tubing or copper strip wound in the form of a solenoid or a pancake. They are called **radio frequency transformers.** They do not possess iron cores although such cores have been employed for radio frequencies between 10,000 and 100,000 cycles.

(2) **Transmitting oscillation transformers** are either of the **conductive** or **inductive type.** Electrostatic coupling has been employed but not extensively. The conductive type may comprise a **single** coil or **helix** or a **variometer inductance.** The **inductive or two-coil type** may take various shapes and forms as will be shown in the drawings to follow.

(3) In the construction and design of oscillation transformers, some of the essential points to be considered are:

(a) The conductor of the primary and secondary coils must have good surface conductivity.

(b) The inductance of either circuit should be continuously variable, i.e., the coils are preferably fitted with sliding contacts so that the turns of either winding can be cut in or out of the circuit inch by inch.

(c) The coupling between the primary and secondary coils must be easily altered.

(d) The coils must be well insulated between turns to avoid leakage.

HIGH VOLTAGE CONDENSERS

(1) **Three types** of high voltage condensers have been employed:

(a) The glass plate tin foil condenser.

(b) The copper foil-micanite condenser.

(c) The copper plated glass jar condenser.

(d) Compressed air condenser (plated in tank under 250 lbs. pressure).

(e) Air condenser (using air at atmospheric pressure as dielectric).

(a), (d) and (e) are employed in connection with high power transmitters. (b) and (c) are used principally for low power marine type of transmitters. (d), however, is not widely used.

(2) For low power transmitters, the **Leyden jar type of condenser** is almost universally employed. A single section of the average condenser using glass as the dielectric whether of the plate or Leyden jar type will withstand potentials up to **15,000 volts** without breakdown of the dielectric. If the applied potential exceeds this value, **series parallel connections** are employed.

SHORT WAVE CONDENSERS

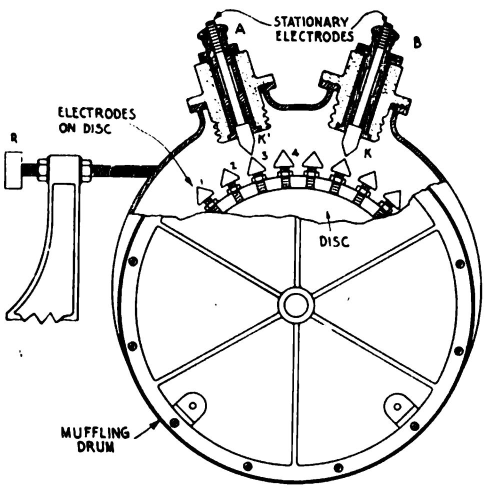
(1) In general, the antenna condenser must withstand a high potential; hence, four or five jars or plates are connected in series.

(2) For the average ship's aerial the short wave series condenser should be approximately .0005 microfarad.

AERIAL TUNING INDUCTANCES

(1) This coil may be of the **continuously variable type** wound in the form of a spiral pancake or in the form of a hoop or helix. Aerial tuning coils for the transmitters must have good insulation between turns and the conductor must have good surface conductivity.

(2) The most popular form at present is the "pancake" type made up of copper strip. A sliding contact controlled by a convenient handle permits the turns to be gone over inch by inch.



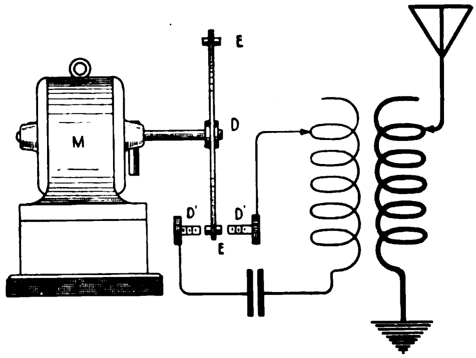


Figure 95

Figure 94

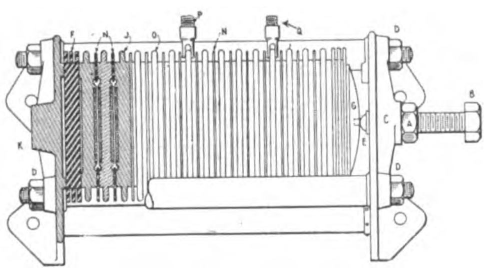


Figure 96

OBJECT OF THE DRAWINGS

(1) Figure 94. To show the construction of a modern synchronous rotary spark gap.

(2) Figure 95. To show the construction and the circuit of the non-synchronous rotary spark gap.

(3) Figure 96. To show in cross section the construction of a multi-plate gap (so-called quenched gap).

PRINCIPLE

The note of the spark discharge at the transmitting apparatus is reproduced in the telephone at the receiving station, and since spark notes of high pitch are more readily read through atmospheric electricity, spark gaps are designed to give musical tones. The best tone is secured when the frequency of the charging current is 500 cycles per second. Transmitters operated from a source of low frequency current are provided with non-synchronous dischargers to produce a higher rate of sparking. Spark dischargers are constructed to quench the primary oscillations after one or two cycles.

DESCRIPTION OF THE DRAWINGS

In figure 94, a revolving steel disc mounted on the end of the motor generator shaft carries the spark electrodes 1, 2, 3, 4, etc.

Two stationary electrodes A, and B, with the discharge points K^1 and K respectively are mounted on a steel **muffling drum** which encloses the spark discharger, and insulated therefrom. Means are provided whereby the length of the discharge gap between the revolving elect ry electrodes can be adjusted to approximately .005 inch.

In figure 95, the **non-synchronous disc discharger** comprises the disc D mounted on the shaft of motor M; on the outer circumference of D are mounted the spark electrodes E, E from 8 to 30 in number depending upon the speed of the motor and the rate of sparking desired. Two stationary electrodes D, D permit the condenser in the closed oscillation circuit to discharge whenever electrode E comes directly opposite. The motor M may be driven by alternating or direct current and means must be provided **whereby its speed can be closely regulated.**

Figure 96 shows in partial cross-section the construction of the **multi-plate spark discharger.** A number of copper plates, J, with the cooling flanges, O, are separated by insulating gaskets or washers, N. A spark surface of one or two inches in diameter is provided at the center of each plate and a groove surrounds the sparking surface so that the insulating gasket does not come in contact with the spark discharge.

These plates are placed in an insulated rack and are tightly compressed by bolt B, which rests against the steel plate G. An insulating plate such as F is mounted on either end of the gap to prevent contact with the metal frame. Bolts D, D, take the strain of the bolt B, and the plates are insulated from D, D by micanite tubing placed over the bolts. Contact is made with the plates by the clips P and Q by which any number of gaps may be connected in circuit.

OPERATION

One of the most important adjustments is the **clearness of the spark note.** It is the duty of the operator to maintain the spark gap in such condition as will afford a **high pitched note** free from irregularities.

The synchronous discharger of figure 94 is adjusted for clear tones by lowering the stationary electrodes K, K-1 until the gap between them and the electrodes on the disc is no more than .005 of an inch in length. Then the position of the stationary electrodes in respect to the disc is changed by turning the rod R to the right or to the left until a uniform note is secured.

The non-synchronous discharger of figure 95 is adjusted for clear spark tones, first, by regulation of the speed of the disc through a **series resistance** or a **motor field rheostat,** and second, by adjustment of the alternating current voltage.

The multi-plate gap of figure 96 is adjusted for clear tones principally by the generator field rheostat, the **voltage being adjusted** until a uniform discharge is secured. In addition, the note is effected by the number of gaps in use. The final adjustment of the note of this gap must be made **after the transmitter has been tuned** to the standard wave **lengths.**

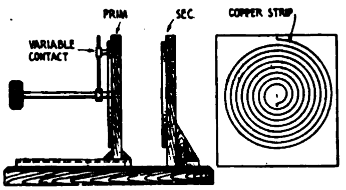


Figure 97

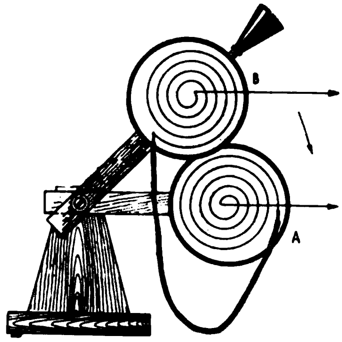


Figure 98

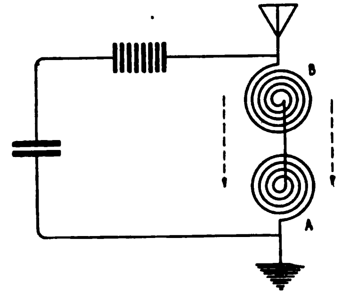


Figure 99

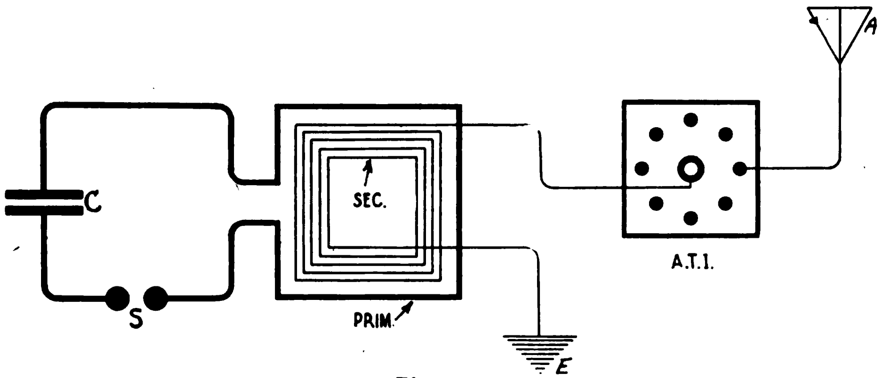


Figure 100

OBJECT OF THE DIAGRAMS

(1) Figure 97. To show the general construction of a pancake type of oscillation transformer.

(2) Figures 98 and 99. To show the principle and use of the variometer as a coupling transformer.

(3) Figure 100. To show the general construction of one type of oscillation transformer wherein the primary and secondary inductances are of fixed value.

PRINCIPLE

The requisite radio frequency current for the production of electric waves is generated in what is known as a closed oscillation circuit, and the energy of this circuit is transferred to the aerial wires through an oscillation transformer.

DESCRIPTION OF THE DRAWINGS

In figure 97, the primary and secondary windings which are made of copper strip are mounted on a base. One of the windings is movable to permit variation of the coupling. It is customary to provide either the primary or secondary with a sliding contact rotated by a handle. This handle also is employed to draw the coils apart for change of coupling.

Figure 98 discloses the general construction of one type of variometer. Two spiral coils of fixed inductance are connected in series. When coil B is parallel with coil A, the self-induction of the variometer is zero. It is maximum when the coils are drawn apart.

In figure 99 the coils of the variometer A, B, constitute a conductively coupled oscillation transformer for transferring the energy of the closed circuit to the aerial wires. The coupling is maximum in the position shown and minimum when the coils are parallel.

In figure 100 the primary winding of the oscillation transformer consists of a single turn of cable especially constructed for conducting high frequency currents. The secondary winding consists of eight turns of stranded cable. The aerial tuning inductance indicated at A,T,I, has eight plug contacts which make connection with the various turns on the antenna tuning coil.

OPERATION

The coupling of the transformer may be varied in two ways. The windings may remain in a fixed position and the mutual inductance varied by cutting in and out turns in the secondary; or, the coils may be drawn apart.

In figure 97, the coupling is varied by drawing the primary away from the secondary. In figures 98 and 99, the coupling is altered by changing the relative position of the coils A, B. In figure 100, the coupling is more or less fixed.

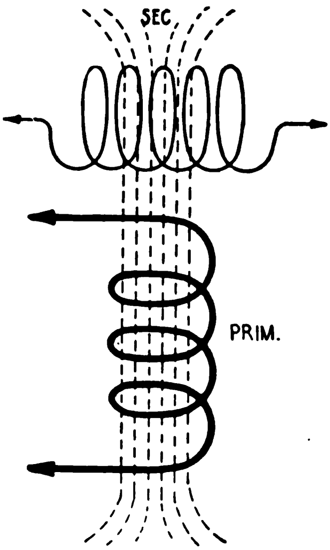


Figure 101

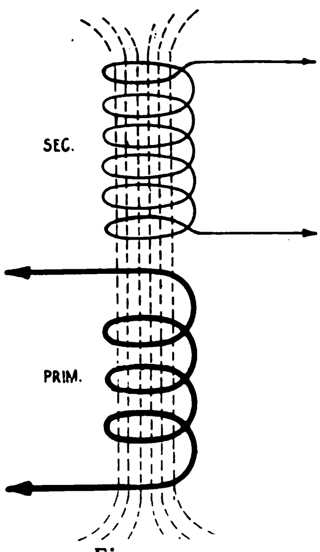


Figure 102

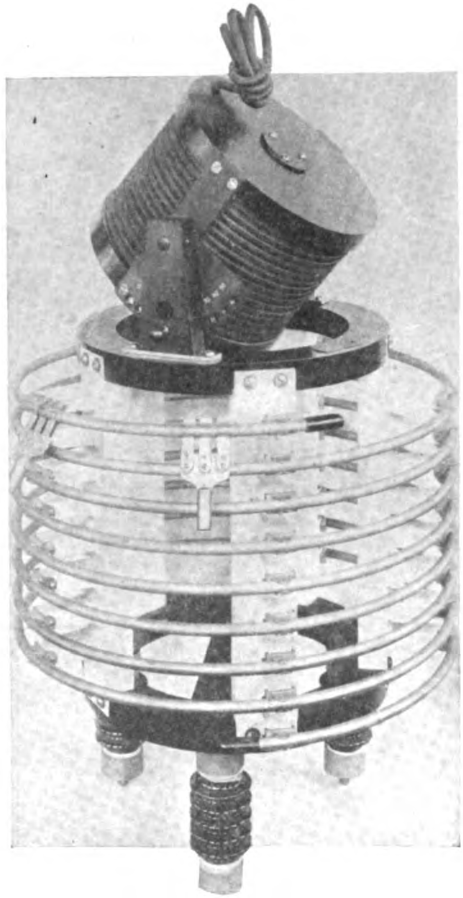


Figure 103

Figures 101, 102.—*Showing how the coupling between the primary and secondary coils of an oscillation transformer is varied by turning the secondary at right angles to the primary. In figure* 101, *the secondary is at right angles to the primary, and no cutting by the lines of force takes place, since they move parallel to the turns. Hence, the coupling of the transformer is practically zero. In figure* 102 *the lines of force set up by the primary cut the secondary at right angles, the coupling being maximum in this position.*

Figure 103.—*Showing the construction of the type A oscillation transformer of the American Marconi Company. The primary winding consists of eight turns of ½ inch copper tubing mounted on specially designed porcelain oscillators. Connection is made with the spark gap circuit by means of two clips (attached to the top turn in the illustration). The secondary winding is a fixed inductance mounted so that it can be turned completely at right angles. In this way, the coupling of the oscillation transformer is adjusted to secure the pure wave required by law. Also, the radiating powers of the transmitter can be adjusted from zero to maximum.*

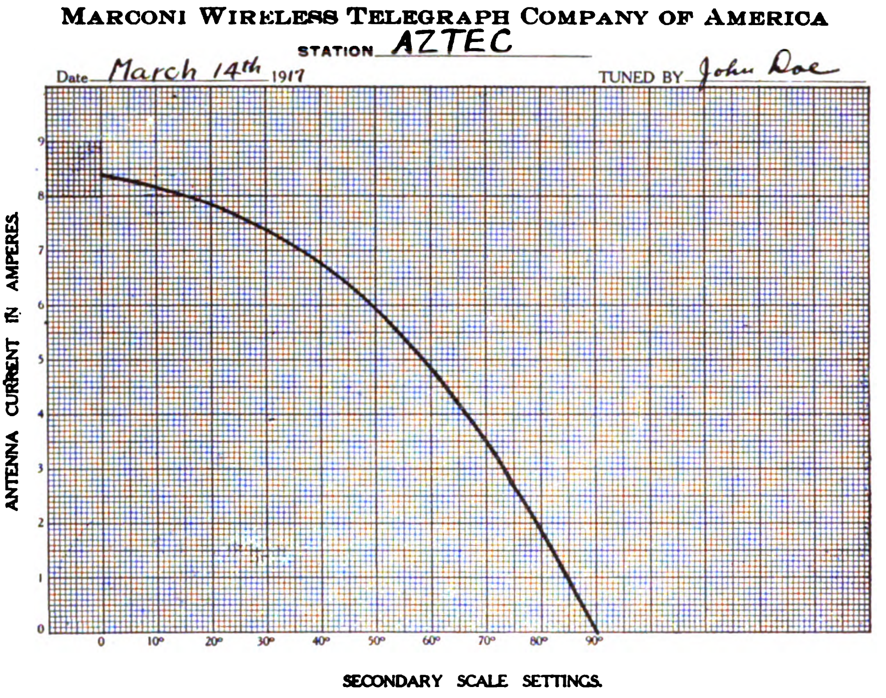


Figure 104.—Showing the reduction of the antenna current by turning the secondary winding of the Marconi type A oscillation transformer at right angles to the primary winding. If the secondary winding bears an angle of 90 degrees to the primary, the coupling is zero, and the antenna current is zero. Increasing the coupling increases the antenna current as shown by the curve. The antenna current is nearly 8½ amperes at maximum coupling. By turning the secondary winding at right angles to the primary, the operator can reduce the power for working over short distances.

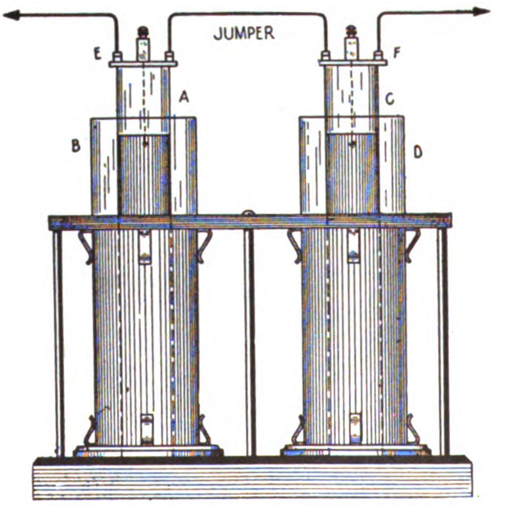


Figure 105.—Showing the construction of one type of short wave condenser used by the American Marconi Company. Four Leyden jars of .002 microfarad capacity each are connected in series, and when not in use they are cut out of the antenna circuit by means of the jumper shown. The complete circuit from binding post E to binding post F is as follows: Connection is made from binding post E to the inside of Leyden jar A. The outside coating of B makes contact with the outside coating of D through the base. The inside coating of D makes contact with the outside coating of C. The inside coating of C is connected to binding post F.

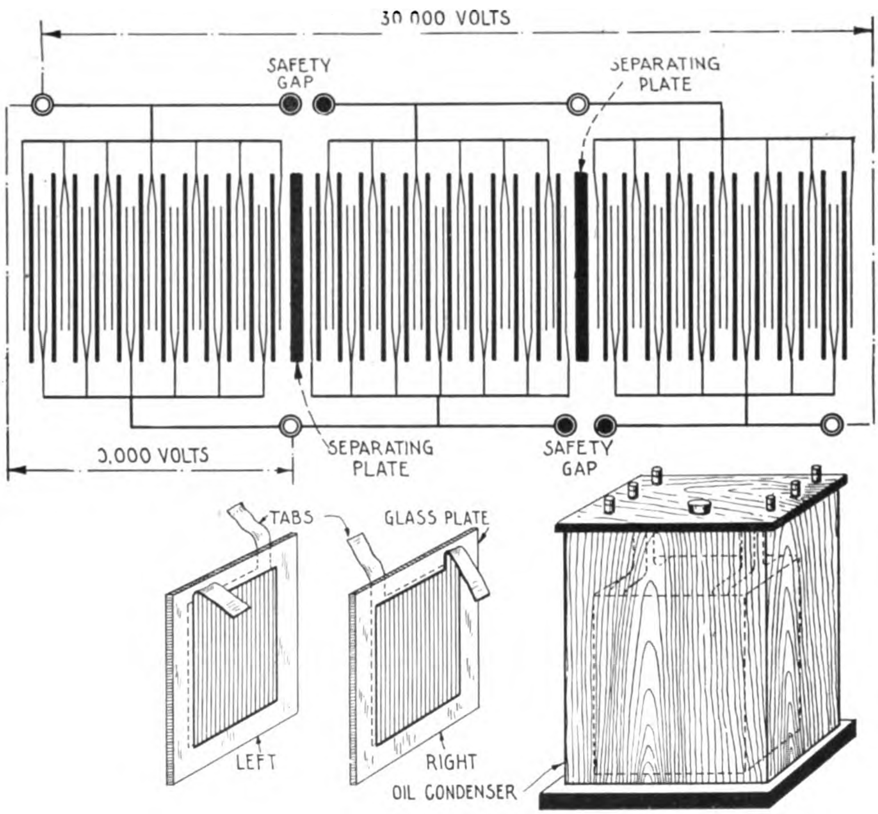
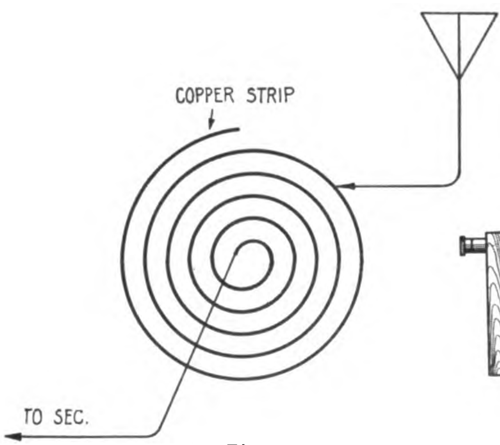


Figure 106

Figure **106.—***Showing* ***the general construction and assembly of an oil plate condenser. A number of glass plates are coated on either side with tin foil connecting tabs being attached to the foil as shown. On*** *one set of plates, the tabs issue from the* ***right side*** *of the foil (when the* ***plates*** *face the operator) and on* ***the other set, from the left side of the foil. In assembly, the RIGHT and LEFT plates*** *are stacked together.* ***The diagram*** *shows three banks of high voltage condensers connected* ***in series.***

If the voltage of the transformer is 30,000 volts, by this connection the strain on each unit is only *10,000 volts. The liability of puncture thus is reduced. After a set of plates* ***have*** *been stacked* ***up they are bound with canvas*** *tape and immersed* ***in a tank of oil, connections being brought out to binding posts on the lid.***



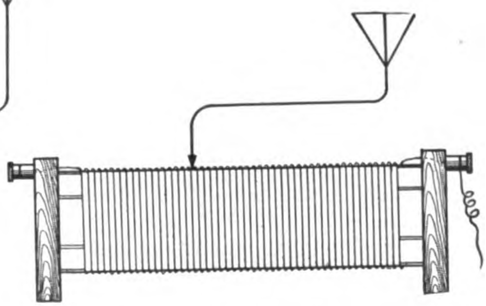


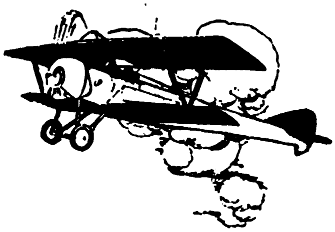
Figure 108

Figure 107

Showing the general *construction of aerial tuning inductances.* ***In figure*** *107* ***the aerial tuning inductance is made of copper strip*** *over which slides a contact connected to the antenna.* ***In figure*** *108,* ***the coil consists merely of a number of*** *turns of copper tubing or* ***heavily insulated copper wire, connection being made to the antenna circuit as shown.***

How to Become an Aviator

The Eighth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

THE earlier articles of this seiies have dealt entirely with the theory of flight and the function and construction of the aeroplane as a flight medium. The student is now ready to consider the propulsion of the machine, upon which all theory of flight obtains.

Flight is made possible, as has already been explained, by the action of the air on inclined surfaces driven through the air at high velocity. The reader is aware that the driving force is a propeller actuated by a gasoline engine. Consideration of the propeller will be brief, as the military aviator is not concerned with the details of engineering mathematics upon which propeller efficiency is based. Some knowledge of the method of checking up the balance of the air screw is all that is required of the pilot, and this is given on the page following.

The study of engines must necessarily be brief, as the varying types of design in internal combustion engines make a full consideration of the refinements of operation a subject of voluminous proportions. What will be attempted in this and a following article will be a brief survey of the general principles which apply to the most familiar types of aviation engines and the essential information for the pilot who takes control of an aeroplane in flight. The aviation engine must have small weight per horse power, minimum head resistance and reliability of operation; for these reasons some minor changes in design from familiar automobile types will be noticed. The first consideration is the stationary water-cooled motor; later, the rotary air-cooled types will be described.

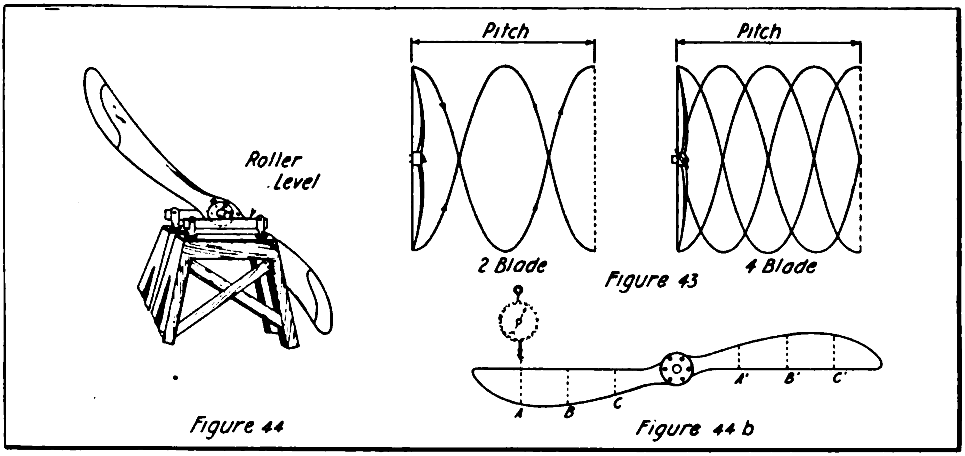


Figure 43—Action of propeller revolutions
Figures 44, 44b—Method of propeller test for balance and area

THE PROPELLER OR "AIR SCREW"

The propeller's revolutions represent thrust, its action in screwing through the air (see figure 43) translating the power of the engine into forward motion. The drift of the aeroplane, due to its resistance, is overcome by opposition of the thrust; it follows, therefore, that the power of the propeller thrust must be greater than the aeroplane's drift, or the velocity will decrease.

BALANCE

The propeller is mounted after the aeroplane is assembled. It should first be tested for balance, for if one blade is heavier than the other it will vibrate when run on the engine. The usual practice is shown in figure 44. A stand is leveled up; a roller is then inserted in the hub of the propeller, which turns freely on the roller; this roller is then allowed to roll freely on the level. Any lack of balance is thus easily detected.

Another method is indicated in figure 44*b*. Place the propeller in horizontal position and measure off three points on the blades equally distant from the center. By means of a spring balance weighing scale, the weights are taken at these points, and must correspond for each side.

Application of more varnish on the lighter side is usually sufficient to equalize a propeller out of balance.

SURFACE AREA

Measurement of three equi-distant points by callipers should show corresponding measurements to exactness of less than 1/8 inch. Figure 44b illustrates this measurement, A being equal to A′, B to B′ and C to C′.

LENGTH

Blades should be of equal length to 1-16 inch.

STRAIGHTNESS

With the propeller mounted on a shaft an object should be fixed in a position where the tip of one blade grazes it. With the point marked, the other blade is brought around and should come within 1/8 inch or graze it.

CARE OF PROPELLERS

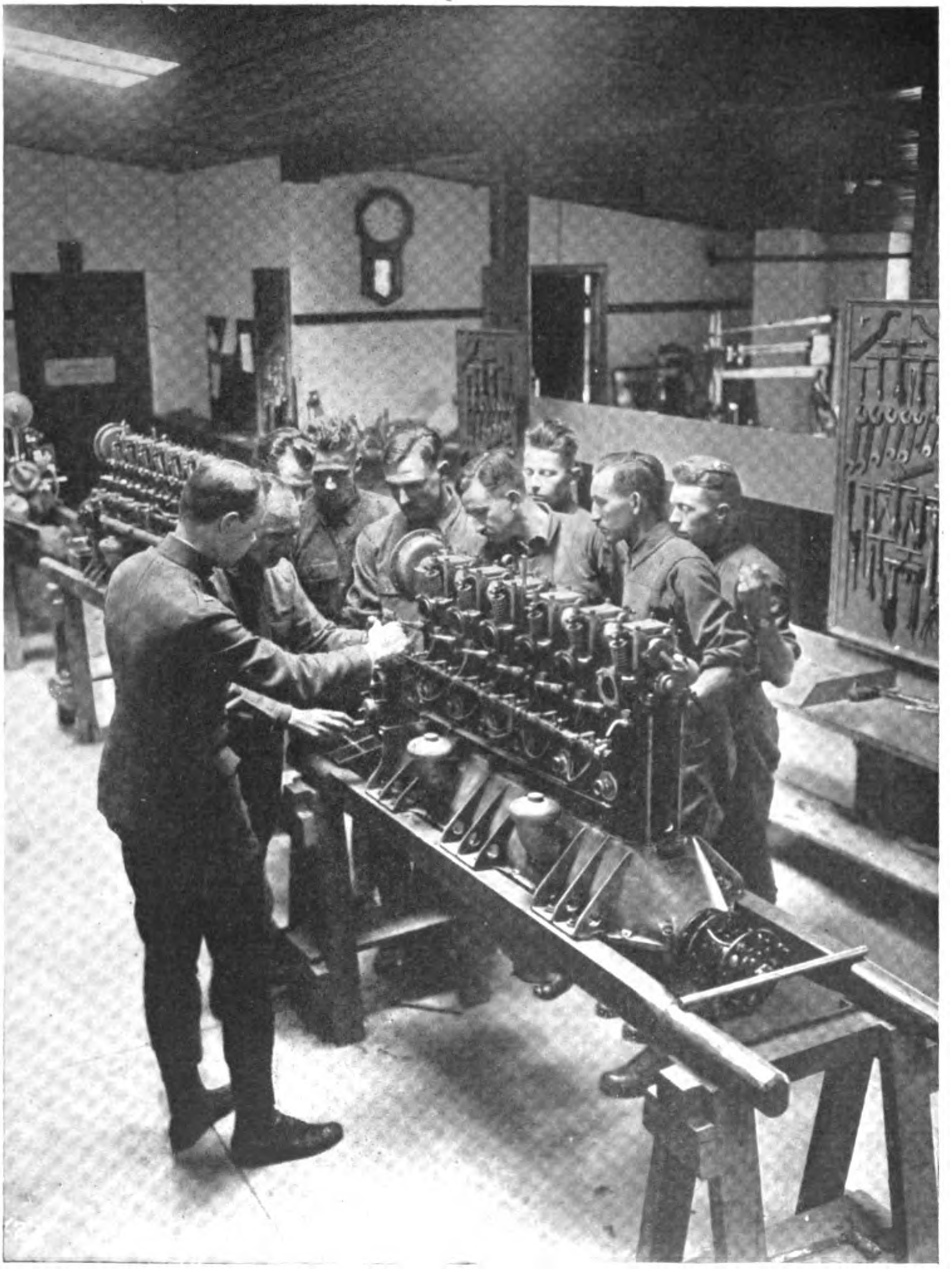
They should never be leaned against a wall or allowed to remain long in horizontal position.

They should not be stored either in very damp, or very dry, places.

They should not be stored where the sun will shine on them.

The proper method of storage is hanging in vertical position on horizontal pegs.

(c) Committee on Public Information



This picture, taken at one of the "Ground Schools" of the Army Signal Corps, well illustrates the earnestness and concentration of the men. The instructor is obviously having no difficulty in keeping his men at work, for these future American airmen know just as well as he how vital it is that they should understand every impulse of the engine which will soon mean so much to them in midair. A most thorough and fundamental course of training in engines is necessary for the men who will carry the responsibility for America's work in the skies

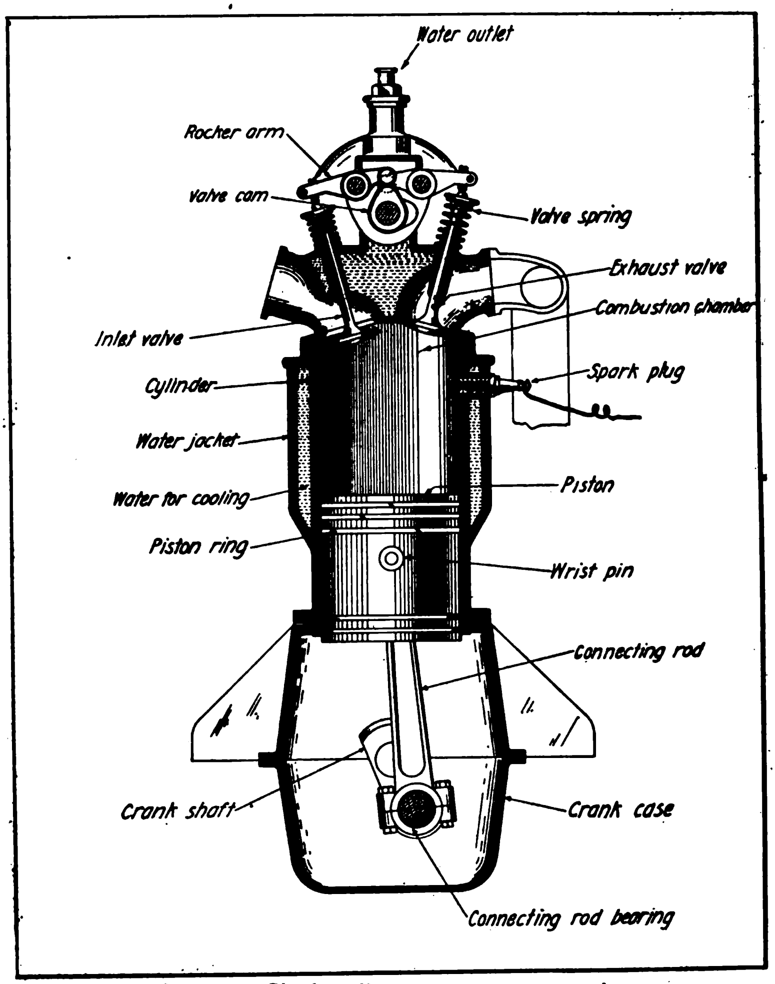


Figure 45—Single cylinder of a gasoline engine

THE GASOLINE ENGINE

Vaporized gasoline mixed with air and set afire by an electric spark results in combustion (explosion), the intense heat from which develops the pressure which operates the engine.

Figure 45 shows a single cylinder of a gasoline engine in sectional view. The names of the parts should be studied.

COMBUSTION CHAMBER

The end of the cylinder which is closed, in which the combustion takes place is known as the cylinder head, the space between it and the piston being the combustion chamber.

PISTON

This is a cylindrical-shaped body which slides back and forth in the cylinder, the combustion (explosion) driving it downward.

CONNECTING ROD

Suspended from the piston is a connecting rod which acquires a *reciprocating motion* as the piston moves up and down.

CRANK SHAFT

The connecting rod is attached to the crank shaft, by means of which the reciprocating motion is changed to a *rotary motion* (as a wheel revolving on its axis) which turns the propeller.

REVOLUTION

A complete turn of the crank shaft, moving the piston down and back, is called a revolution.

THE FOUR-CYCLE PRINCIPLE

There are two types of internal combustion engines using gasoline for motive power; viz.: the two-cycle and the four-cycle. These may be distinguished by considering them as two-stroke and four-stroke engines. The two-cycle engine has no valves, the gas entering and exhausting through ports in the cylinder walls, covered and uncovered at proper intervals by the travel of the piston up and down. The four-cycle engine, which will be considered exclusively in the text following, as its use is almost universal in aviation, has intake and exhaust valves operated by mechanical means.

Figures 46, 47, 48 and 49 show the action of the four-cycle engine, clearly indicating the operations during the four strokes.

INTAKE STROKE

Suction caused by the piston starting downward, as the engine is "cranked," draws the explosive gasoline vapor into the combustion chamber of the cylinder. It enters through the intake valve, which is the only opening. The exhaust valve is closed, the intake valve being so adjusted that the cam opens it mechanically as the suction action of the piston commences.

COMPRESSION STROKE

Both valves are closed as the piston starts on its up-stroke and the explosive mixture in the cylinder is compressed into the small space of the combustion chamber as it reaches the top of the stroke.

The explosive value of compression is illustrated by the action of gunpowder, which, ignited in the open air burns slowly but is instantly exploded if confined to a small chamber.

POWER STROKE

As the piston reaches the top the spark is timed to jump the spark gap points and ignite the explosive vapor. The piston is driven down by the expansion of the gas, making the power stroke.

EXHAUST STROKE

As the piston returns from the power stroke the exhaust valve is opened, the pressure from the explosion forcing out the burned gas. The upward move of the piston pushes out all of the burned gas that does not escape by its own pressure.

The exhaust valve closes as the piston reaches the top, and the inlet valve opens to admit a fresh charge of gas into the cylinder. The operation is then repeated as long as the engine runs.

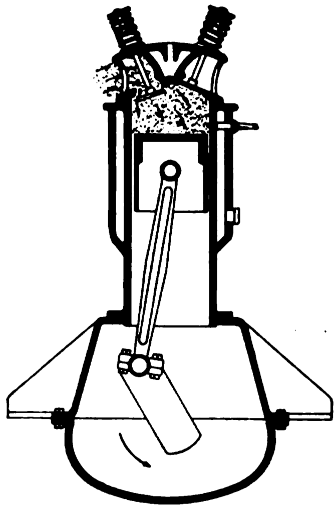


Figure 46

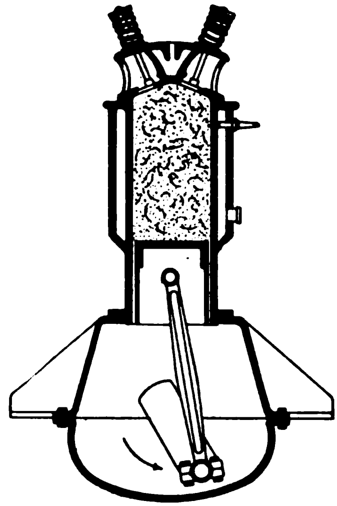


Figure 47

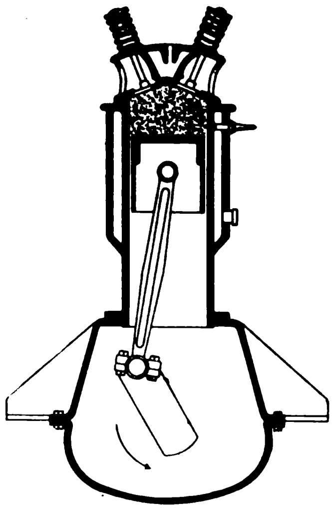


Figure 48

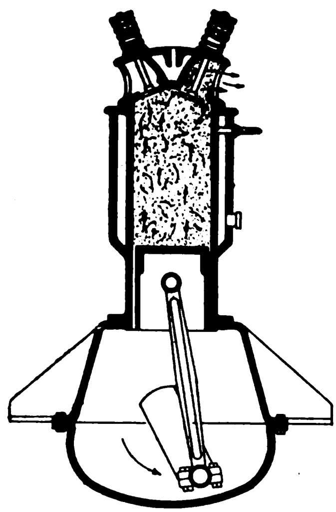


Figure 49

Figure 46—Intake stroke. Figure 47—Compression stroke. Figure 48—Power stroke. Figure 49—Exhaust stroke

THE FOUR-CYCLE PRINCIPLE

FIGURE 46

This is the intake stroke. The inlet valve is open and the gas is entering the cylinder, drawn by the suction of the piston.

FIGURE 47

This is the compression stroke. Both valves are closed and the piston is returning, the upward stroke compressing the gas.

FIGURE 48

This is the power stroke. The electrical spark from the spark plug ignites the gas. Both valves are closed as the combustion drives the cylinder downward.

FIGURE 49

This is the exhaust stroke. Only the exhaust valve is open, the upward movement of the piston forcing the burned gases out of the cylinder.

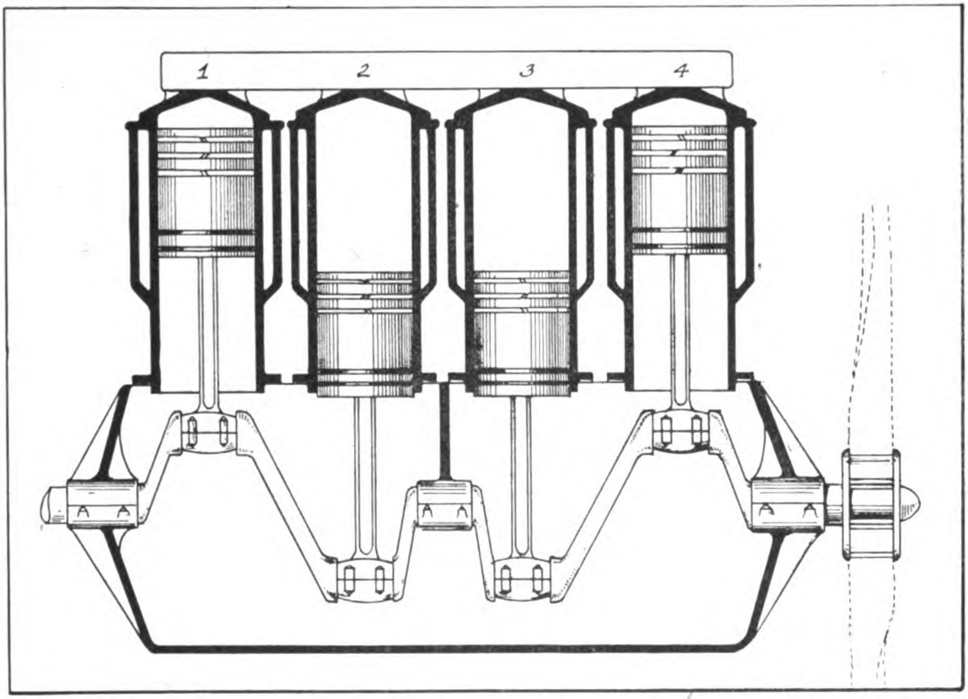


Figure 50—*Cross section of a four cylinder engine*

MULTIPLE CYLINDER ENGINES

A cycle operation requires four strokes to two revolutions. Only one of the four strokes is a power stroke; therefore, in a single cylinder engine the piston must be carried through three dead strokes. This ordinarily requires a heavy fly wheel, which when started will continue to revolve. It is obvious that the more cylinders an engine has the steadier will be the power impulses, since the successive explosions may be timed to follow so closely that one of the pistons will always be on a power stroke. Thus in aviation engines where weight is a material factor, the heavy fly-wheel is dispensed with by use of multiple cylinder engines.

4-CYLINDER OPERATION

Four cylinder engines deliver a power impulse every stroke, or two power impulses to every revolution.

Figure 50 shows a four cylinder engine in cross section.

It will be noted that the crank shaft which delivers motion to the propeller is set at 180 degrees, the end pair being a half-revolution from the inside pair.

As piston No. 1 descends on the power stroke, No. 2 is coming up on exhaust; No. 3 is ascending on compression and will be fired next; No. 4 is taking in gas.

FIRING ORDER

The rotation in which the explosions take place in the cylinders is therefore 1, 3, 4, 2.

This engine could as well fire 1, 2, 4, 3, but it will be obvious that explosions in the order 1, 2, 3, 4 would require a crank shaft alternately projecting to each side, 1 and 3 being up when 2 and 4 are down. This construction has the following disadvantages:

(a) A crank shaft weaker and more difficult to make.

(b) A rocking motion, or vibration, from side to side.

The alternate distribution of power impulses, where cylinders are fired in the order shown in the illustration, makes for smooth running.

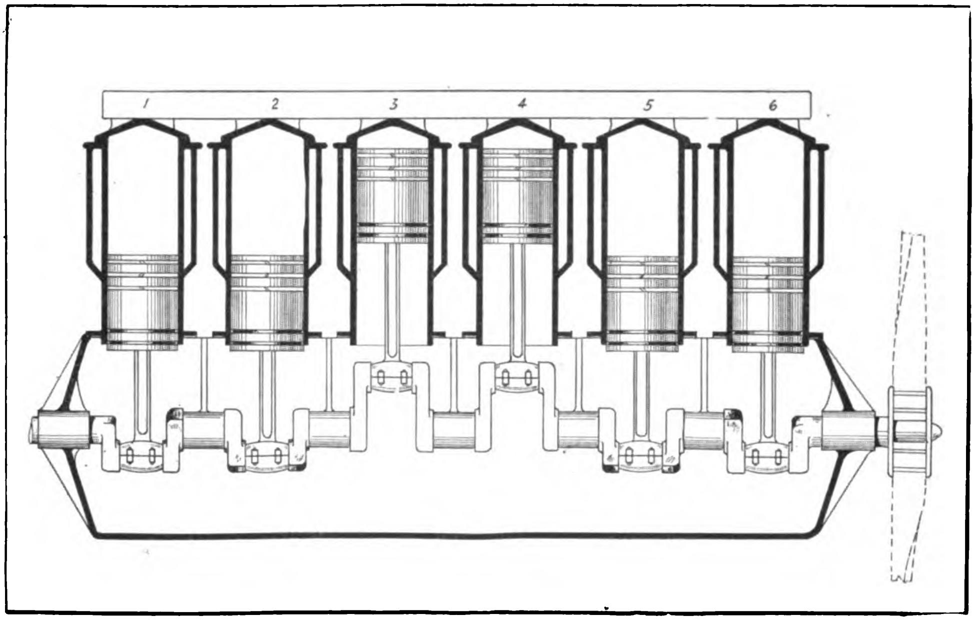


Figure 51—Cross section of a six cylinder engine

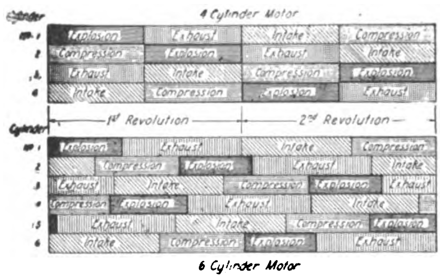


Figure 52—Graphic illustration of cylinder operation in four and six cylinder engines

6-CYLINDER OPERATION

The six cylinder engine is four-cycle, the same as the four cylinder engine. The principal differences in construction are in the addition of more cylinders and consequent change in crank shaft.

Figure 51 shows a cross section of the six cylinder engine.

It will be noted that the crank shaft is arranged to turn two revolutions during four strokes, as in the case of the 4-cylinder engine. The crank shaft is therefore divided into three pairs of throws, i.e., each pair is placed at 120 degrees, or 1-3 of a circle apart.

FIRING ORDER

In figure 51, cylinder No. 5 has just fired, No. 3 is ready to fire, after which the order will be 6, 2, 4, 1.

With 4-cylinder engines an explosion takes place each half-revolution; the 6-cylinder engine in the same half-revolution has 1½ explosions. That is, power impulses are continuous in 6-cylinder engines, in fact they overlap; this results in smooth running.

Figure 52 is a graphic representation of the sequence of cylinder operating in 4-cylinder and 6-cylinder types of engines.

The ninth article of this series, which will appear in the April issue, will continue the study of gasoline engines, considering carburetion and ignition.

MILITARY AIRMEN

A. LEO STEVENS

Chief Instructor of the Army Balloon School at Fort Omaha

Mr. Stevens has been active with balloons for twenty-five years, making ascensions, experimenting and manufacturing

IN APPOINTING A. Leo Stevens Chief Instructor of the Army Balloon School at Fort Omaha the Government has added to its forces doubtless the most experienced balloon pilot in America. No one has been associated so intimately with the development of the science of ballooning as Mr. Stevens, or has proved his ability to fill the post by such wide and varied experience. It is some twenty-five years since Mr. Stevens first attracted public attention by his daring balloon ascensions in many widely scattered sections of the country. About this period he became a manufacturer of balloons, when the free balloon was alone in the field and the dirigible was not yet thought of. Mr. Stevens has manufactured some 1,500 balloons of various types and has made in all more than 2,000 ascensions.

When the dirigible balloon began to attract attention Mr. Stevens was among the first to design and build a power-driven balloon and to actually fly it. His first flight with a power-driven balloon at Manhattan Beach, September 15, 1902, startled the country. His first flight lasted for forty minutes. He was also among the first balloon pilots to go aloft with a passenger. His daring and success in these early days of the new science will hold an important place in the history of American ballooning. Mr. Stevens contributed to the development of the power-driven balloon in America, and its present development is largely due to his ingenuity and energy. He has also been very active in developing the kite balloon, and in operating it.

When the Government looked about for the best talent to enlist in its balloon work it was recognized the long experience of Mr. Stevens would be of vital importance. He was selected to act as inspector of the balloon factories engaged in Government work and proved of great assistance in this activity. Later he was appointed Chief Instructor in the Government's first lighter-than-air flying station at Fort Omaha. His appointment was authorized December 1, 1917. Mr. Stevens gave up his extensive business as a manufacturer of balloons on receiving his appointment and has directed all his energies to the service of the Government. He has remained a civil instructor and has refused a commission of major.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

ARTICLE V

CHAPTER IV (Continued)

Current

A BODY of water set in motion and carrying with it all floats thereon is called a current. Among the best known is the Gulf Stream. This generates in the Gulf of Mexico, obtaining its greatest speed or force in the Strait of Florida, setting in a North and Eastward direction, it crosses the North Atlantic, rendering mild temperature over and in waters adjacent to England, Ireland and Scotland; even the Northern part of Norway is influenced and therefore has mild winters with ice-free harbors all the year round.

The direction in which the current flows is called the *set* and the speed or velocity is called *drift*.

CHAPTER V

Chart Sailing (Piloting)

Chart sailing or Piloting is the term generally used when the ship's position is found by observations or measurement of angles between terrestrial objects or when in any other way the ship is conducted through channels or along the coast, in sight of land or land marks, using the markings such as buoys, beacons, light houses, light ships, points of land, mountain peaks as marks in order to find the ship's way from port to port or until clear of land. The same term also applies when using the lead or sounding machine to obtain the depth of water and thence deduct the ship's position.

Piloting is the most important part of navigation and requires the greatest care, because if a mistake is made there may not be time to discover it before an accident occurs.

Cross Bearings

The simplest form of finding the ship's position is by cross bearings. This consists of observing the bearing or direction of two known objects, correcting the bearings for deviation so as to reduce these to magnetic bearings, then referring to the chart, from the objects two lines in a direction opposite to the bearings and where these lines intersect one another is the position of the ship. The following diagram, figure 44, illustrates this:

A ship sailing along the coast observed two points *A* and *B*.

A bearing by the compass W ¾ N.

B bearing by the compass N by E.

From our deviation card we find the deviation is ½ point W. Required the position of ship.

The compass bearing of *A* is W ¾ N. Deviation ½ pt. Westerly. Assuming we stand in the center of the compass looking in the direction of *A* and following the rule for applying deviation; Westerly Deviation to the right, we find the magnetic bearing of *A* to be W ¼ N. Now place the parallel

rulers over the center of the compass rose, with the edge over W ½ N and E ¼ S and move the rulers (taking care to preserve the parallel) until the edge comes directly over the point *A* and draw a long pencil line from *A* in

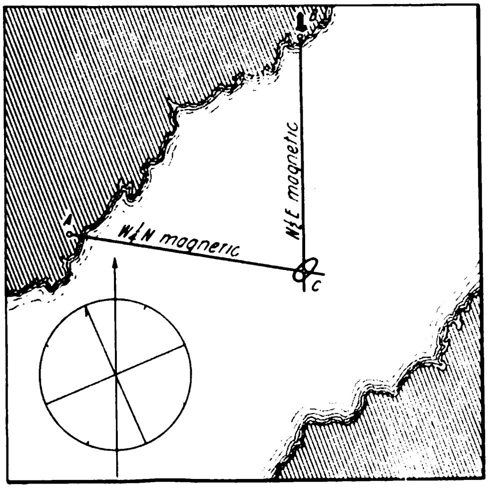


Figure 44

the direction toward the sea. The compass bearing *B* was N by E. To this apply ½ pt. West Variation according to the rule and we find the magnetic bearing of *B* to be N ½ E. Using the parallel rulers in connection with the compass rose as before, draw a line from *B* until it crosses the line from *A*. The position of the ship at *C* is found to be at the intersection of the two lines.

Ship's Position by Two Bearings of the Same Object

When only one known object is seen, the method just described may be employed to find the ship's position. It is frequently very useful, especially during hazy weather, or intermittent fog. As a practical illustration let us suppose that the fog lifts for a short period and we can see a light at night or lighthouse during day. As soon as we are sure that we recognize the light we take a bearing of this by the compass, and at the same instant note what the log indicates; also the time and the course the ship is steering. If fog now sets in again we must wait until it clears sufficiently to see the light again, then take another bearing and read the patent log again. Now we have two different bearings; the course steered by the compass as well as the distance obtained by the difference between the two readings of the log. Correct the bearings as well as the compass course for deviation, if any, and using the parallel rulers, plot the two magnetic bearings. Using the compass rose we now place the parallel rulers in the direction of the ship's magnetic course, measure off the sailed distance with the dividers from the scale on the chart and keep this distance between the points of the dividers. Taking care to

keep the parallel rulers in the direction of the ship's magnetic course, move them until a plane is found between the two bearings where the distance corresponds to the sailed distance and draw a line; where this line which represents the ship's course intersects, the second bearing is the ship's position.

Example

A ship steering E by N observes a lighthouse *L* bearing N N E by compass, log showing 36 miles, continuing on the same course until the log registers 38½ miles, the bearing at that instant was N ½ W. Deviation ½ pt. E. Required the position of the ship.

In solving the problem, correct the first bearing for deviation and draw the line from the lighthouse *L* as shown in the diagram, figure 45, using the compass rose and parallel rulers. In a similar way, plot the second bearing. Then from the scale measure up 2½ miles with the dividers and having laid

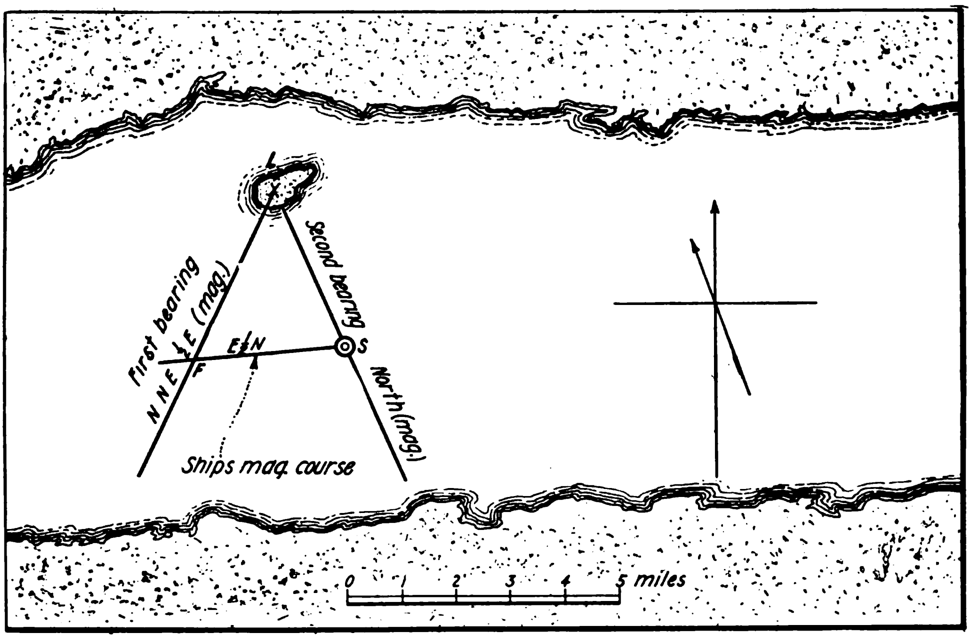


Figure 45

the parallel rulers in the direction of the ship's magnetic course (E ½ N) move same until the edge comes to a place where the sailed distance 2½ miles corresponds with the distance between the plotted bearings and draw a line F. S. The position of the ship is at S where the ship's course intersects the second bearing.

(To be continued)

ERRATA

In the January number, Chapter IV at the end relating to leeway the following sentence occurs: "The angular difference between this and an imaginary line pointing straight aft is the leeway, or in other words, the difference between the lubber line and *ship's compass course.*" The last lines should read: or in other words, the *angular difference between the lubber lines and the ship's actual way through the water.*

A Digest of Electrical Progress

The Effect of the War Upon Electrical Industries Abroad—Education in War Time—A Seaplane Minus Wings—Telephonic Time Service in Switzerland—Detecting Breaks in Transmission Lines by Wireless Telegraphy—The Electrical Vehicle Coming Into Its Own—Longest Power Transmission Span in the World—Air Blast Rectifier for High Tension Alternating Current—Lag on Wireless Time Signals

The Effect of the War Upon Electrical Industries Abroad

IT is difficult at this writing to predict just what the final effects of the European War will have on the habits and customs of the people of the world, but it is certain that far-reaching revolutionary conditions will result. There is some consolation, however, in the thought that such events are in reality but the beginning of a new order of things. No matter how severe the price paid by humanity, marked progress in many directions is frequently the outcome.

Commenting upon the effects of the war upon the electrical art in England, an Englishman's views are set forth in a recent issue of The Electrical Review.

The first regret is for the loss of life among the ranks of professional men in the war—men who, had they lived, would undoubtedly have contributed greatly to scientific progress:

"It is lamentable to think with what prodigality there have fallen out of life, while engaged in actual fighting, young men of proved or potential genius who might have conferred untold benefit upon millions by continuance in the exercise of inventive ingenuity and research. What the world has lost in this way never can be known, of course; and it is useless to deplore it now; some of them entered, fired with patriotism, before it was evident how scientic and engineering a war would be. Yet, notwithstanding this lamentable loss, we cannot help recognizing how great has been the effect upon thousands of men of their kind who still continue their work and have labored during these two or three years under the impelling influence of emergency and absolute necessity, calling imperatively for the best that they could give, the best that they could contrive. In such a matter we never shall be able to tell whether our gains have been greater than our losses, but we certainly know that we should have been richer still had statesmen appreciated at an earlier state the value of the scientific mind."

The increased importance that the war has given to science and scientists is remarked upon, and it is declared that the engineer has had his status raised substantially by the part he has played, whether in the field or in the munition works. Additional comment was as follows:

"No state in future will be able to cold-shoulder its engineers, its chemists, electrical experts; they have proved their value as a veritable

national bulwark. What they have done will not only help in the conduct of the war but the application of much that they have done, to the industrial and general life in peace time, will be noted and continued for years to come. . . . . In this connection when all can be told it will be found that the part that electricity has performed forms one of the most fascinating chapters of the war. Experience and discovery in these departments are not limited to soldiers; the civilian benefits too; they are also international."

Education in War Time

WE cannot neglect our educational institutions if we are to maintain consistent progress in the present national crisis. We should profit by the mistakes of our Allies who at the outset committed the error of thinking that this war would be of short duration. We must not repeat this blunder. We must educate a great army of technologists who will be prepared to take the rank of the depleted body of foreign scientists.

So important is the matter of the education of rising America that the Counsel of National Defense held a conference with university officials in Washington last May to consider the situation as a whole and to prescribe means for keeping our schools filled during the war time. A definite connecting link between the educational institutions of the country and the National Government in matters pertaining to war is maintained by the Bureau of Education and the States Relation Service of the Department of Agriculture. These two bureaus co-operate with the Education Section of the Advisory Commission of the Counsel for National Defense.

In a circular recently issued, Dr. Claxton, Educational Commissioner, says:

"When the war is over, whether within a few months or after many years, there will be such demands upon this country for men and women of scientific knowledge, technical skill, and general culture as have never come before to any country. The world must be rebuilt. This country must play a far more important part than it has in the past in agriculture, manufacturing and commerce. . . . Russia and China are awakening to new life and are on the eve of great industrial development. They will ask of us steel, engines and cars for railroads, agricultural implements, and machinery for industrial plants. They will also ask for men to install these and to direct much of their development in every line."

The proposal to keep our universities and educational institutions filled during the war is commented upon by The Scientific American as follows:

"If we are in for a long war then it is equally important from a military point of view to add to the brain power of the nation by increasing the attendance at universities, colleges, normal schools and technical schools—now constituting a little more than one-half of one per cent. of the total population of productive age. Tuition fees should be lowered as much as possible. The hours of classes and the length of the course should be arranged so as to give students better opportunities for working their way through college. The abolition of the long summer vacation and the adoption of a school year of four terms of twelve weeks has been suggested as a means of enabling some students to complete their education more rapidly, and others to give a large proportion of their time in school or college to productive work. We must have more and more technically trained men, whether for war or peace—more doctors, more engineers, more experts in every line."

One of the most promising professions in the technical engineering field is that of radio engineering. Even now the requirements for the services of a skilled

wireless engineer or telegrapher are so great that in all probability special courses will have to be inaugurated in our universities throughout the country. Practical workers, above all, are immediately required, but the services of a certain number of skilled scientists who can guide and conduct operations on strictly scientific lines are positively essential.

A Seaplane Minus Wings

WE are advised in a recent issue of The Scientific American that the French are making use of a novel water glider which is designed directly after the ordinary seaplane with the exception that it does not possess weight. The advantages of the arrangement, of course, are the absence of water propeller troubles and the great rate of speed with which it can travel over the surface of the water. Consequently it makes an excellent machine for the hunting down of submarines and for scouting. The Scientific American describes the machine as follows:

> "The wingless seaplane consists of two main pontoons and a tail float, supporting a framework which carries a two-passenger nacelle and the usual tail members of an aeroplane. The tail members are used for steering the craft. The power plant is placed at the forward end of the nacelle and drives the tractor screw. Capable of a high rate of speed, it is obvious that this wingless seaplane performs invaluable service as a patrol scout in the hunt for German U-boats, in conjunction with its aerial counterparts and surface craft. Because of its shallow draft and high speed it is practically immune from attack by U-boats, and it is quite possible that it may be used in a small sort of a way in attacking the periscopes of the German subsurface raiders, which probably accounts for the rifle held in the hands of the observer in one of the accompanying views. At any rate, the wingless seaplane appears to be a valuable adjunct in the U-boat campaign, for work in calm weather and in covering large areas."

Telephonic Time Service in Switzerland

THE Swiss Government evidently deemed it advisable at the outbreak of the European War to suspend the operation of all private wireless stations, and conseqently the jewelers of Switzerland were hindered considerably in obtaining the radio time signals from the Eiffel Tower in Paris. It seems that the Swiss clock and watch makers were put to such inconvenience by the lack of this service that arrangements were made by the federal telegraph and telephone service to supply these signals over the telephone lines.

The plan has been in operation since May, 1916, and accurate observations made at the federal observatory at Zurich show that the accidental errors involved in the transmission of the signals rarely exceed a tenth of a second.

Detecting Breaks in Transmission Lines by Wireless Telegraphy

IT is reported in a recent issue of the Electrical Review that amateur radio telegraph apparatus has been used in a novel way by a local power company in Chattanooga, Tenn. Some employes of the power company are officials of the Chattanooga Wireless Club of Tennessee, and they have been able to tell by their wireless telegraph equipment when the power transmission lines break. The arc caused by breaking of wires or, in fact, by leakage, causes a pecular hissing sound which can readily be detected by a sensitive wireless receiver and in this way the power company is warned of the trouble.

Many instances other than those referred to, whereby leakage in power lines has been detected by a radio telegraph receiver, have been recorded. An aerial, for instance, erected in the immediate vicinity of a power line in which there is leakage on the insulators (arcing between a 2200-volt line and a wet tree), can immediately be detected by the wireless receiver. A peculiar, rasping, intermittent note, similar to the discharges produced by atmospheric electricity, will be produced in the receiving head telephone. Amateurs, on more than one occasion, have been able to report leakages on power lines when the power company was not aware of the trouble.

The Electrical Vehicle Coming Into Its Own

THE threatened shortage of gasolene as an automobile fuel is bound to give an impetus to the further development and use of the electric vehicle. The reliability of this method of automobile propulsion has long since been established, but its chief limitation is, of course, the small mileage obtained for a single charge of the battery. But even with this defect it may become necessary to adopt this type of automobile power throughout the period of the war and for some time afterward.

The technical press, fully aware of the situation, is urging the adoption of the electric automobile and its wider use in all lines of work. The general public does not seem to be aware that the electric automobile has long ago passed the experimental stage, but this lack of knowledge is probably due to the more spectacular performances of the gasolene automobile.

The Longest Power Transmission Span in the World

THE 4,427-foot span across the Carquinez straits in California for the transmission of electrical power has been considered an engineering feat of the highest order, and to date, has the record span of the world. However, we are told in a recent issue of the Journal of the Royal Society of Arts that the Shawinigan Power Company will soon undertake to span the St. Lawrence River with a 5,000-foot transmission line that will carry current at pressure of 100,000 volts.

It is remarked that in order to have these cables clear the water by the 160-foot minimum permitted by law it will be necessary to make the towers on either side 350 feet in height. This is the same elevation as the top of the Quebec Bridge.

These towers will rest on concrete foundations located in the river 500 feet from each shore. The foundations will consist of four circular concrete columns, eleven feet in diameter, descending to a depth of forty feet below the river bed and twenty-five feet above it. The concrete foundations will be protected against the action of ice by a low crib dam located about 100 feet up stream and arranged so that the ice will pile up and break into small pieces before it can reach the tower foundations. The four legs of the towers will be anchored in these four piers, the towers being built of structural steel.

It will also be necessary to widen out the top of the towers into a platform in order that the cables may be kept fifty feet apart. This will prevent them from swinging together in a heavy storm.

As is to be expected, the cables will not be anchored at the top of the towers, but are brought down to the rear of the towers to an anchor in the ground, located at a considerable distance from the towers' base. The supports are especially designed to permit a certain amount of movement in the cable due to expansion which may be caused by changes in temperature.

Special insulation had to be devised because of the extreme pressure of 100,000 volts. The magnitude of the problem will be better understood when we consider that these insulators are not only subjected to the electrical strain, but will also have a mechanical stress each of 150,000 pounds. The insulators must also be so arranged that any breakage which may occur will not permit the cables to part and fall into the river.

Air Blast Rectifier for High Tension Alternating Current

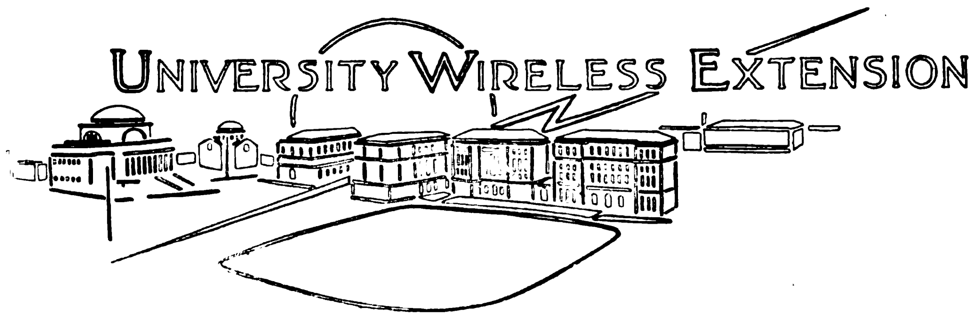
IT has been known for a number of years that if a high tension alternating current is discharged from a point to a plate, partial rectification will occur, but some difficulty has been experienced in applying this method, especially if a considerable amount of power is involved. E. J. Erickson and E. R. Woolcot in a recent issue of the Physical Review show that complete rectification can be obtained by utilizing a current of air flowing from the discharge point to the plate. The apparatus is described in detail and oscillographic curves are reproduced to illustrate the effect obtained. With the air blowing, the discharge obtained by rectification is quite rhythmic, but an ordinary colored arc results when the air blast is removed.

The authors assert that considerable difficulty was experienced at low voltages but good results were recorded with about fifteen kilovolts, the current amounting to from twelve to twenty-five milli-amperes. Up to 350 kilovolts, at a frequency of 500 cycles per second, practically complete rectification was obtained.

Lag on Wireless Time Signals

A SERIES of observations were recently made by F. D. Urie to determine the time lag between the Arlington and Great Lakes (Lake Bluff, Ill.) wireless stations' time signals, both of which are received by wire from the Naval Observatory and converted automatically into radio signals through the medium of electromagnetic relays. There are between 750 and 900 miles of telegraph wire between Washington and the Great Lakes station, the circuit including telegraphic repeaters at the radio station. The lag between the two radio stations, as observed in Washington, was found by a series of tests to average .085 second with an error of approximately .002 second.

This time interval is, of course, due to the lag in the telegraphic relay at the radio station which repeats the time signals into the radio transmitter. This difference in time observation has often been observed by radio operators along the Atlantic coast when the ships on which they were stationed were in localities which permitted copying time signals simultaneously from two naval stations.



Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE XV

(g) **STRAYS.** We have previously considered "Stray Interference in Radio Telephony" to some extent, and have shown a number of methods of reducing such interference. We shall now consider some further points in connection with strays and radio telephony. To begin with, it must be noted that with the modern sensitive receivers (e.g., the regenerative vacuum tube receivers), heavy strays do much more damage than to act merely as incidental noises. They break up the incoming sustained wave trains so far as the receiving system is concerned and thus prevent resonance phenomena in circuits of small (or even zero or negative) damping from being fully utilized. In addition, some types of detectors (e.g., sensitive crystals or gas-containing bulbs) may be "paralysed" by heavy strays and take some little time to regain their sensitiveness. Even very high vacuum tubes may show this effect, since a very powerful stray impulse may charge the grid negatively to such an extent that the plate current will be practically cut off until the grid charge escapes by the normal leakage. Then, too, the ear will be so shocked by heavy bursts of strays that it will take some little time to regain its normal sensitiveness.

The Author has found, in connection with some tests in radio telephony over fairly considerable distances, that really good reception requires that the signal audibility shall be 3 times that of the strays, and that the strays shall not occur continuously even then but intermittently, and not more frequently than say once or twice per second. Fair recepton can still be accomplished even if the (intermittent) strays are 2 times as strong as the signal. Reception becomes difficult if the strays are 5 times as strong as the signal, and almost impossible if the ratio is greater, particularly if the strays are continuous.

Dr. C. J. de Groot has given in the "Proceedings of The Institute of Radio Engineers" for April, 1917, a classification of the strength of tropical strays (with a crystal detector and normal Telefunken receiver) and the signal

strength necessary for telegraphic communication through such strays. The number of the class is on an arbitrary scale.

0. No disturbance. (Signal strength would be a few times audibility).
1. Weak strays. Requiring a signal of 10 times audibility.
2. Medium strays. Requiring a signal of 20 to 30 times audibility.
3. Strong strays. Requiring a signal of 60 times audibility.
4. Heavy (or very heavy) strays. Requiring a signal of 250 to 500 times audibility.
5. Overwhelming strays or thunderstorms. This case occurred only for an hour or two during the very worst days in the least favorable part of the year. Reception under such conditions is not possible.

Dr. de Groot showed that musical spark signals could be read through strays that had (at least intermittently) an audibility nearly 70 times as great as that of the signal and an audibility at almost all times of 10 or 20 times that of the signal. This he imputes to the remarkable selective sensitiveness of the ear to musical tones. This advantage is not present to the same extent in radio telephony.

Dr. de Groot further classified strays into three classes electrically and gave the details of the production, nature, and elimination of each class.

Type 1. These are strays originating in nearby thunderstorms, and they have only a short range. They are found to be of periodic character (i. e., decadent wave trains of definite period and decrement). They are heard in the receiver as loud, widely separated clicks, and may be eliminated by audio or radio frequency compensation. The arrangement given by de Groot for this purpose is shown in Figure 201 and is explained by him as follows: "Two receiving antennas, L_1, L_2 of the same shape and dimensions were installed near enough together (10 or 20 meters or 30 to 60 feet apart) to make them respond in the same way to strays. (For the aperiodic disturbances, this distance could be easily increased, but for periodic disturbances the distance of separation must be small compared to the wave-length of the strays, in order to get the induced e.m.f.'s in phase). On the other hand, the antennas must be placed sufficiently far apart so that the signals set up in the one whch is made aperiodic (L_2) shall not cause currents in the tuned antenna (L_1). One of the antennas, L_1, is tuned to the incoming signal and coupled to the detector circuit D_1 in the ordinary way. The detector D_1 will rectify signals as well as strays and send the rectified current into the telephones; or, as in the case of the Figure, into the differential transformer T_r. The antenna L_2 is tuned either to the same, or preferably to a longer wave-length, thus making it less sensitive to the signals and more sensitive to the long wave strays. The detector D_2 is switched directly into this antenna, thus making it aperiodic or nearly so. This arrangement makes it almost impossible to receive any distant signals on the antenna L_2, but loud signals on wave-lengths different from those to which L_1 is tuned and strays give a response that is nearly as loud as can be obtained on the tuned antenna L_1. The rectified current is sent to the same telephone mentioned before; or, as in the Figure, to the differential transformer T . However, this second current from the aperiodic antenna L_2 is arranged to act in the opposite direction from that of D_1. The

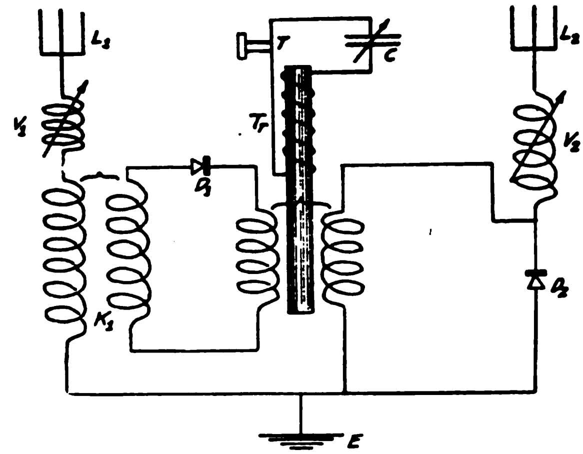


Figure 201—de Groot audio frequency compensation method for the elimination of periodic strays

telephone T is either connected in series with D_1 and D_2; or, as in the Figure, in a third winding of the differential transformer and in series with the condenser C to permit tuning to the spark frequency. Since D_2 does not respond to distant signals, there will be heard in the telephones the signals from D_1 only, whereas the strays rectified by D_1 and D_2 tend to compensate. By varying the coupling K_1, this compensation may be made complete." Dr. de Groot mentions that the detectors must both have the same characteristic and states that carborundum crystals with suitable auxiliary potential meet the requirements. The theory here given yielded very promising results when tested. For further details of this method, the reader is referred to the original article.

Type 2. These strays are associated with low-lying (electrically charged) rain clouds and are of very short range. Electrically, they are found to be intermittent uni-directional currents due to actual discharges to or from the antenna. They are audible as a constant hissing sound, and are eliminable by the Dieckmann electrostatic shield shown and explained in connection with Figure 11.

Type 3. These are most common or night strays and cause most of the interference with reception. They are believed to originate in the Heaviside layer or conducting portion of the upper atmosphere when this is subjected to the cosmic bombardment of small particles and comets. The range (with the receiver used) was several hundred miles, and these strays gave a continuous rattling noise. They were successfully eliminated by means of the Dieckmann cage of Figure 11.

Much valuable information on the daily and seasonal variation of strays is given in Dr. de Groot's paper. The reader is also referred to the Author's discussion on that paper for a further explanation of the Dieckmann cage.

The first approximation to the ratio of heavy summer strays to light winter strays is probably between 100-to-1 to 1,000-to-1 or even more.

(h) **RANGE IN RADIO TELEPHONY.** As has been previously stated, the effective range of a radiophone transmitter depends on the loudness of strays at the receiving station; and consequently any method of reducing strays will increase the effective power of the transmitter in just that proportion.

In 1908, Mr. Fessenden, as the result of some rather elaborate analysis, reached the conclusion that the amount of power required to cover a given range radiophonically was from 5 to 15 times as great as that required to cover it radio telegraphically. It is certain, however, that some of the reasoning there given is not valid, and particularly that dealing with the greater amount of power required in radio telephony because of the relatively small amplitude of the higher harmonics in the human voice. It seems much more likely that about the same amount of power is required to cover a given distance by means of either system of communication.

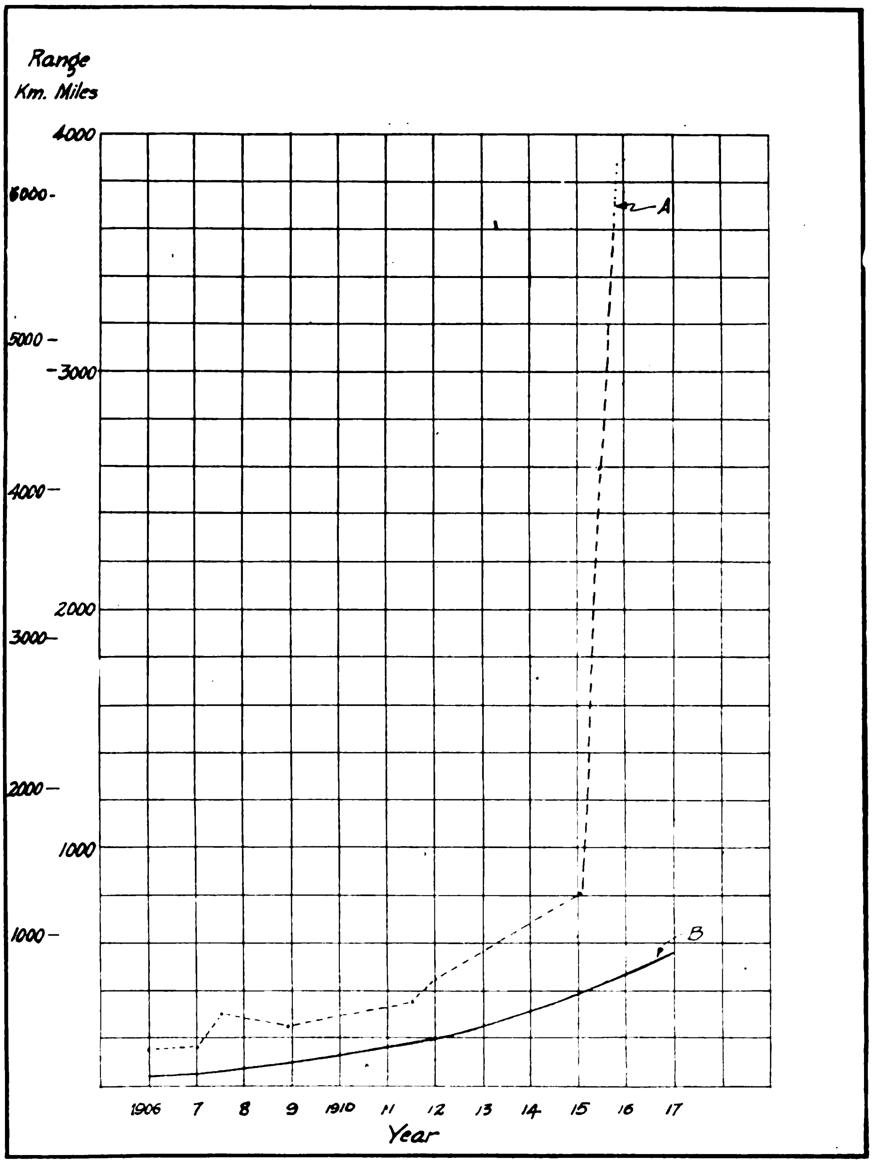


Figure 202—Yearly increase in range in radio telephony

We have compiled from the material presented in this volume the maximum distance covered each year radiophonically. The data is given in the chart of Figure 202. It will be noticed that, practically speaking, radio telephony began in 1906 when a range of 160 miles (250 km.) was covered. It must be mentioned, however, that Fessenden had transmitted speech by a radio-frequent spark method a distance of 1 mile (1.6 km.) as early as 1900. The range increased fairly steadily at the rate of about 60 miles (100 km.) per year until 1915, when it took a sudden jump to the extreme range of 5,100 miles (8,000 km.). The dashed curve *A* shows this material clearly. We have, however, endeavoured to distinguish between distance actually covered as an extreme achievement and the distance which could have been reliably covered with the apparatus

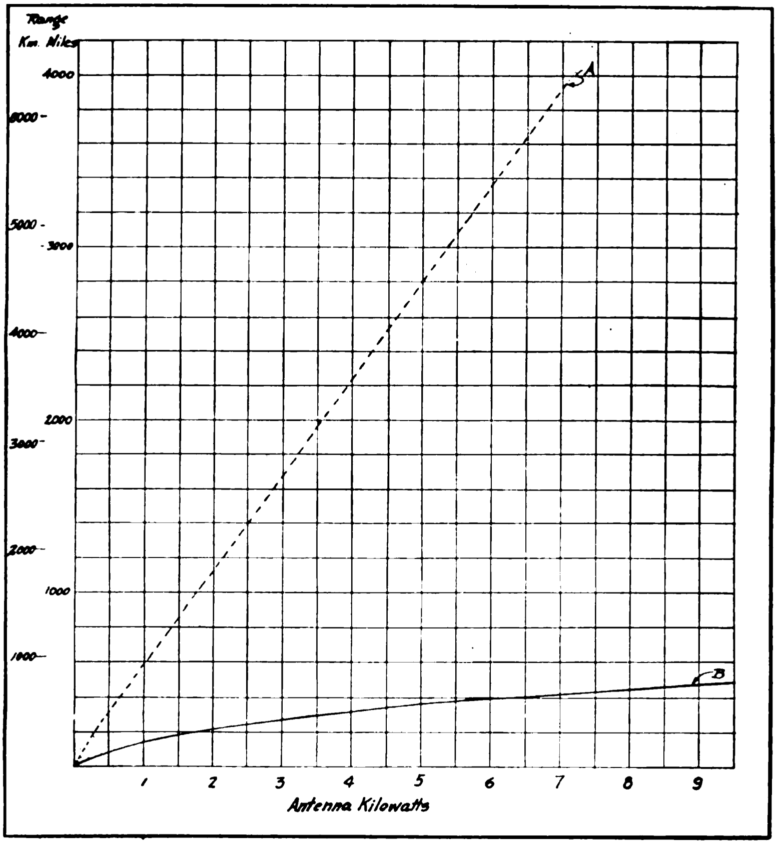


Figure 203—Relation between range and antenna power in radio telephony

available at any given time. The second curve *B* gives the range of probable reliable communication at any given year. It will be seen that this range has risen from about 40 miles (65 km.) in 1906 to about 500 miles (800 km.) in 1917. In fact, it is believed that with the equipment the performance oscillograms of which are given in Figure 186 (that is, the Alexanderson alternator-magnetic amplifier combination controlling 35 kilowatts) reliable overland telephony over 1,000 miles (1,600 km.) or more could be accomplished. We desire to emphasize particularly the distinction between "extreme range" and "range of reliable communication." It is to be regretted that we have had so much of the former type of achievement in radio telephony and so very little of the latter. In view of the large ratio between them, it is felt that only the latter type is of any real interest, and that it only should be stressed hereafter.

In Figure 203 are given two curves connecting the range in radio telephony with the *antenna kilowatts* (*not* transmitter input). These curves are also based on the data given in this book. The upper curve *A* gives "extreme ranges," and shows the following interesting facts. With an antenna power of only about 0.5 kilowatt, 300 miles (500 km.) can *sometimes,* though rarely, be covered. With

1 kilowatt, this rises to 600 miles (1,000 km.). At 10 kilowatts, it rises to 5,000 miles (8,000 km.). The "range of reliable communication," given in Figure 203, curve V is very different. It will be seen that 1 antenna kilowatt will cover reliably about 150 miles (250 km.) overland at the most desirable wave-length. For about 10 antenna kilowatts, this range rises to 500 miles (800 km.). The difference is very significant between curves A and B, and these curves cannot be brought closer together until the matter of stray elimination is settled. Even then, daylight and summer absorption of the electromagnetic waves will prevent the curves from being identical.

10. RADIOPHONE TRAFFIC AND ITS REGULATION.

(a) DUPLEX OPERATION. Any one who has compared normal telephone conversation with the irritating substitute provided by an ordinary speaking tube will realize the full necessity for duplex operation, i. e., simultaneous transmission and reception without the necessity for handling any switches or other devices when the speaker desires to listen, or vice versa. Experience teaches that sending-to-receiving switches lead to endless annoyance and confusion unless there is some skilled person standing next to the user of the radiophone to explain in detail how the switch is handled and to rectify errors of manipulation. While this latter procedure may be possible with a ship radiophone station, where the passenger desiring to telephone to land may put himself under the temporary guidance and instruction of the skilled radiophone operator, it would not be feasible on land since any system of land radio telephony must provide that calls can originate at any wire line subscriber's station, whether at his home or place of business. Since the land subscriber cannot, therefore, come to the radiophone station there will be no opportunity to give him the necessary personal supervision and instruction.

A practical system of duplex radio communication (applicable to telephony) has been worked out by Senatore Marconi. The arrangement at the duplex sending and receiving station is shown in Figure 204. The transmitting antenna A is a long horizontal antenna, and directive (at any rate, for moderate distances and in reception). The main receiving antenna, A_1, is directive and parallel to the first. Both of these therefore point to the distant station. In addition to the main receiving antenna, A_1, there is a balancing antenna A_2 so placed as to receive strongly from the transmitting antenna A but very little from the distant station. The distance CD in practice is anywhere from 25 to 50 miles (40 to 80 km.). A telegraph or, in our case, telephone line connects the stations. The receiver at BD is so arranged that it is coupled to the coils in both antennas A_1 and A_2 *differentially*. By suitable adjustment, it then becomes possible to cut out completely the signal from A while retaining the signal

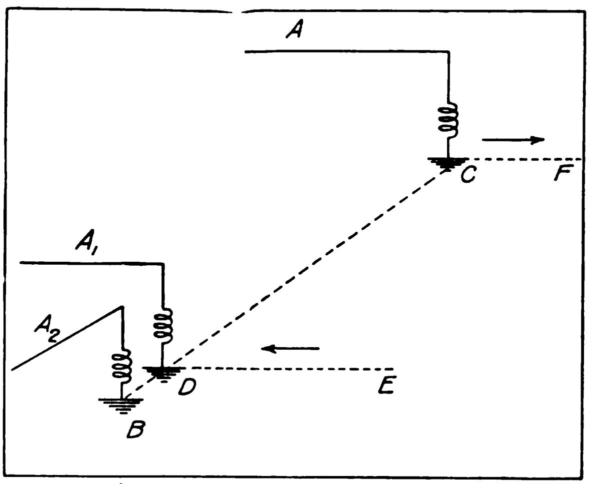


Figure 204—Marconi duplex station

from the distant transmitter almost undiminished. Thus simultaneous transmission and reception become possible.

Another method, due to Mr. Fessenden, is indicated in principle only in Figure 205. The four batteries *A, B, C,* and *D* are connected in series assisting as indicated. Resistances R_1 and R_2 are inserted as shown. Under these conditions, the points *X* and *Y* will be found to be at the same potential, and a sensitive galvanometer connected across them will show no deflection. Translated into the corresponding radio equivalent, the actual arrangement is shown in Figure 206. The radio frequency alternator *J* (in series with the microphone *M* or other controlling device) sends current through the coils *H, G, E,* and *F.* There are thus induced in the coils *C, D, A,* and *B* assisting currents. The resistance R_1 of Figure 205 is replaced by the artificial antenna R_1 of Figure 206, and the R_2 of Figure 205 by the actual antenna of Figure 206. The four coils in the antenna circuit correspond to the four batteries. As will be seen, the points *X* and *Y* in Figure 206 are at the same potential so far as the alternator is concerned, and a receiving set may be connected across them when the arrangement is properly adjusted. This receiver will respond (to some extent) to incoming signals. This entire arrangement, while very ingenious, suffers from a number of practical disadvantages. To begin with, the exact balance is very difficult to secure and even more difficult to maintain because of changes in antenna and ground conditions. Furthermore, the points *X* and *Y* while at equal potential, are far above ground potential, and consequently capacity currents will flow from the receiving set to ground, disturbing the balance and giving false signals. In addition, at least half of the available energy will be lost in the artificial

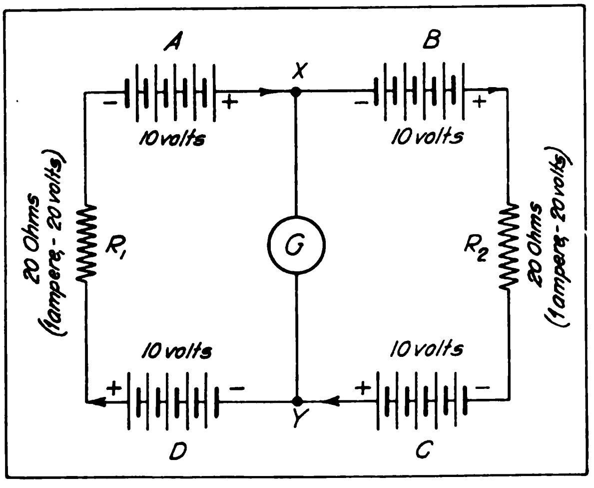


Figure 205—Principle of Fessenden duplex system

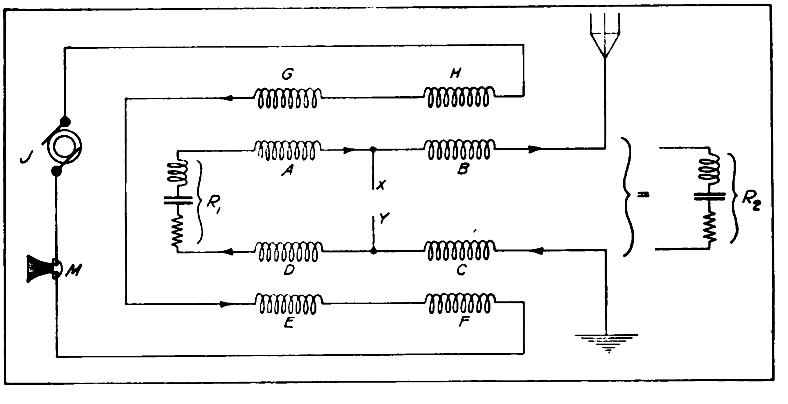


Figure 206—Fessenden duplex system for radio telephony

antenna R_1 and more than half of the incoming signal energy will be lost in all cases.

A somewhat similar arrangement, invented by Mr. J. H. Carson and assigned to the American Telephone and Telegraph Company, is shown in Figure 207. It will be seen that the secondary L' of the output transformer of the radio frequency alternator Q has two equal parallel load circuits. One of these is the path C_1, L_1, and the artificial antenna A_1, while the other is the exactly similar path C_2, L_2, and the actual antenna A_2. The receiving set is coupled differentially to the two paths, and will therefore respond only to incoming signals. It contains the loop circuit L_5C_3 intended to cut down any unbalanced energy at the transmitting wave length which may chance to get into the receiver.

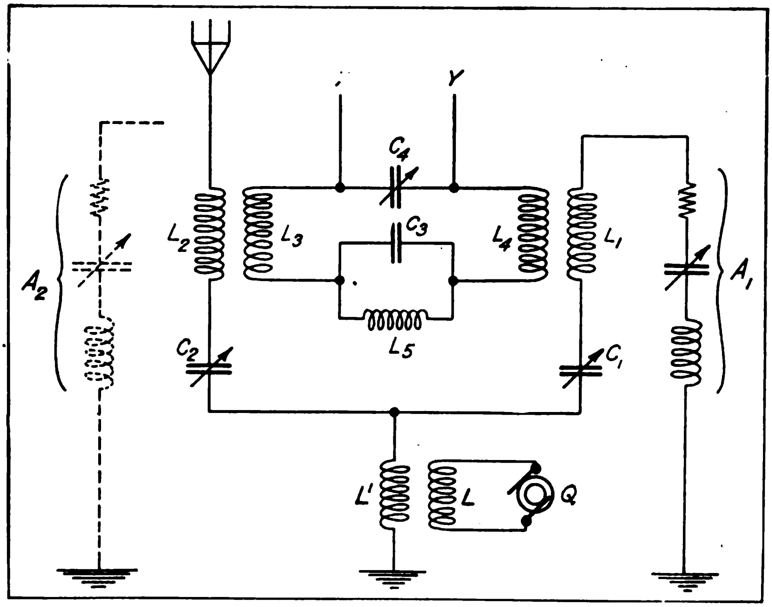


Figure 207—American Telephone and Telegraph Company-Carson system for duplex radio telephony

This arrangement is subject to exactly the same defects as those pointed out in connection with Mr. Fessenden's above.

Another type of system intended to accomplish the same results as actual duplex working has been worked out by Dr. de Forest and along independent lines some of the engineers of the General Electric Company. This consists of a voice-controlled relay which changes the set over from receiving to transmitting when speech is begun. A sluggish contact device (e. g., mercury in a capillary tube) is closed by the voice vibration or the exhaled breath and the set is then thrown, through the action of more robust relays, into the transmitting setting. The controlling device is usually located in or very near to the microphone transmitter. Other systems along similar lines have been proposed, all depending on changes caused by the voice or voice currents, but there is no data available for publication as the extent to which they are capable of practical application.

We will not discuss here such methods of duplex working as the commutator method, wherein the antenna is thrown in rapid succession from the transmitter to the receiver and back. While these may be suitable for telegraphy, they are obviously unsuited for telephony because of their almost certain destruc-

tion of the quality of the speech. Even if the commutation is done above audio frequency (which, in itself, is hardly very practical), the method would be open to grave objections.

(b) **SHIP-TO-SHORE RADIO TELEPHONY.** The most casual consideration of the question of ship-to-shore radio telephony forces us to accept the conclusion that this vastly important system is dependent for its full development on the voluntary or enforced co-operation of the wire telephone companies. It is obvious that it is not possible to have a fairly large radiophone set at the home or office of every one who may at some time or other desire to speak with a person on board a ship, but that the land end of the conversation must be carried on from a large commercial radiophone station which automatically relays the speech out from the wire lines. Similarly the incoming speech from the ship must be received at the same or another radiophone station and there relayed back to the wire lines and thence to the subscriber. The procedure may be made clear from Figure 208. We will suppose that Mr. Frank Jones, whose wire telephone number in New York City is Dyckman 386, desires to radiophone to Mr. William Smith on board the steamship "Curalo," some 500 miles (800 km.) at sea. Let us suppose that a duplex radiophone system (using, for example, the twin station Marconi plan given in Figure 204) is installed at the two towns near New York which have the assumed names of Clairview and Lindhurst. We shall take the transmitting station to be Clairview. At Clairview there will be a usual telephone connection, itself connected to a private telephone line between Clairview and Lindhurst. Lindhurst is the receiving station (with its balancing antenna as indicated in Figure 204). At Clairview, the incoming telephone line has inserted in it or across it the input side of a line amplifier which increases the energy of the speech current to the point of enabling control of the radiophone transmitter at Clairview. The wire line terminating in Lindhurst is there connected to the output side of an amplifier which increases the intensity of the incoming radiophone signals to the point where they can be sent through Clairview to the calling or called subscriber's station. On board the "Curalo" we have a moderately skilled operator, who, among his other duties, listens for distress calls. Either the operator or one of the ship's engineers keep the ship's radiophone set in order. We shall assume that the set on board the ship is not equipped for duplex

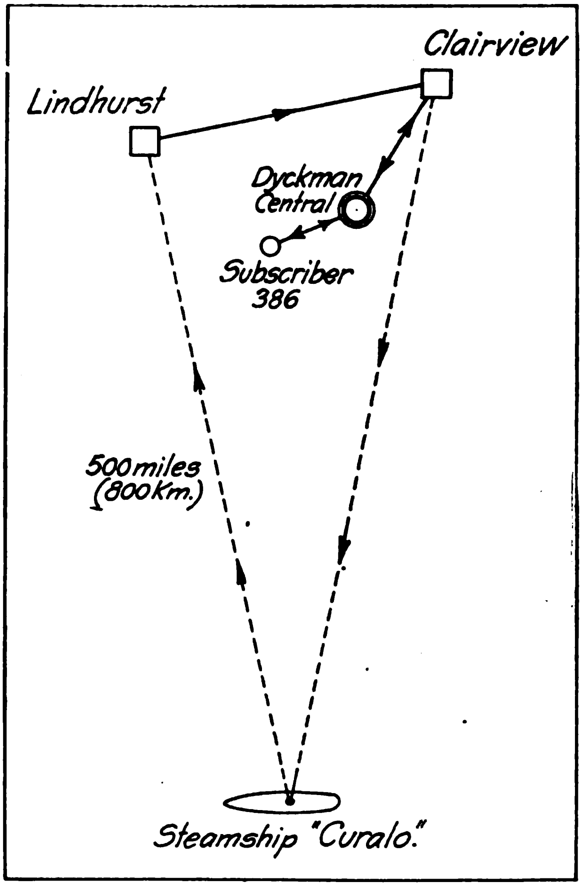


Figure 208—Typical ship-to-shore radiophone system

work, though it is probable that eventually even the ship sets will be duplex. The change-over will be assumed to be accomplished by pressing down a push button when talking and releasing it when receiving, the push button circuit actuating some form of relay control switch which transfer from sending to receiving or vica versa.

We shall now proceed to give in detail the conversation between practically all the parties involved in the above call between Messrs. Jones and Smith. It is understood that this will be somewhat imaginative and subject to revision in details, though it is probably a fairly faithful impression of the actual procedure:

MR. JONES (on his wire telephone): Radio long distance, please.

OPERATOR (AT DYCKMAN CENTRAL): One minute, please. (She connects his line to the Clairview Radio Station line. The internal procedure at the central or centrals is here omitted.)

OPERATOR (AT CLAIRVIEW): Radio long distance speaking.

MR. JONES: I wish to speak to Mr. William Smith on board the steamship "Curalo."

OPERATOR (AT CLAIRVIEW): Mr. William Smith on board the "Curalo." What is your number?

MR. JONES: Dyckman 386, Mr. Frank Jones, the subscriber, speaking.

OPERATOR (AT CLAIRVIEW): Thank you. Hang your receiver on the hook. I will call you as soon as your connection is ready.

OPERATOR (AT CLAIRVIEW, talking out on the radiophone): Hello. Curalo. Hello, Curalo. Hello, Curalo. New York calling.

OPERATOR (ON "CURALO"): Hello, New York. "Curalo" talking.

OPERATOR (AT CLAIRVIEW): I want Mr. William Smith. Mr. Frank Jones of New York calling.

OPERATOR (ON "CURALO"): Mr. Frank Jones calling Mr. William Smith?

OPERATOR (AT CLAIRVIEW): Yes, please.

OPERATOR (ON "CURALO"): Hold the air, please. I will call Mr. Smith. (The operator on the "Curalo" then calls Mr. Smith to the radio cabin, and explains to him how to change from talking to listening by releasing the controlling push button. The method being learned, he resumes as follows):

OPERATOR (ON "CURALO"): Hello, New York. Mr. Smith is ready for you now.

OPERATOR (AT CLAIRVIEW, on wire line): Hello, Dyckman. Clairview calling. Give me 386 again, please.

OPERATOR (AT DYCKMAN): 386?

OPERATOR (AT CLAIRVIEW): Yes, please.

MR. JONES (at his wire telephone): Hello. This is Dyckman, 386. Mr. Frank Jones speaking.

OPERATOR (AT CLAIRVIEW): Mr. Smith is ready for you now. Go ahead, please. (The operator at Clairview here closes the necessary amplifier circuits and takes a supervisory role only.)

MR. JONES: Hello, Mr. Smith. Jones calling.

MR. SMITH: Hello, Jones. This is certainly a pleasant surprise. How are . . . . .

It will be seen from a careful reading of the above that the procedure is no

more elaborate than for any ordinary "particular person" long distance call. Furthermore, so far as the calling and called persons are concerned, there is no more difficulty or confusion than in any ordinary call. To verify this, the reader is urged to re-read Mr. Jones' and Mr. Smith's remarks above.

It need hardly be said that the system of charging for a radiophone conversation would be on the basis of time and not on the basis of words as in telegraphy. As to the extent of the charge, this might depend on several factors. To begin with, a somewhat deferred service corresponding roughly to "day letters" or even to "night letters" in ordinary telegraphy seems feasible at a considerably lower rate per minute. The season of the year and the distance over which the call has been made might also be factors of the situation, though to what extent only practical experience and the development of the art can determine.

There is one direction in which radio legislation properly conceived can greatly assist the radiophone field. This is by providing a system whereby every ship and its corresponding shore station have available not one or two, but a considerable number of wave lengths. These wave lengths, which should be designated by letters or numbers for the sake of brevity. would all be available for communication except those that were in actual use *near the receiving station*. That is, the receiving station, after listening for a moment, would dictate to the transmitting station the suitable wave length for communication without interference. Naturally all calling would be done on a common wave length which might be, for example, the present-day 600 meter wave. This system of a multiplicity of legal wave lengths and the choice of one of them for communication in accordance with traffic conditions at the receiving station has great possibilities, and should be carefully considered for future action.

One further interesting possibility of radio telephony on board ship may be mentioned. A simple phonograph recording and reproducing device run by a small motor might be provided so that, in case the passengers and crews are forced to desert the ship after a serious accident, the phonograph can continue to repeat into the radiophone transmitter the necessary call for help, the name of the ship, its location, the type of accident, and the action taken by the passengers and crew. This would, to some degree at least, relieve the operator from the heroic, but frequently fatal, stand which up to the present he has always taken. With this simple device installed, he has at least the same chance of rescue as the other officers of the ship.

(c) **LONG DISTANCE RADIO TELEPHONY.** This also must be accomplished with the co-operation of the wire telephone companies, and it is to be hoped that they will adopt a broad policy of co-operation with radio telephony in this regard. Since a large portion of the long distance radio telephony will be trans-oceanic (in which case wire telephony cannot come into competition), such an attitude on the part of the wire telephone companies will involve no inordinate sacrifice, and will, indeed, probably add very largely to the long distance land wire line tolls.

We shall give here also the sample procedure of a long distance radiophone call over the 5,500 miles (9,000 km.) between New York City and Buenos Aires. We shall suppose that Mr. Frank Jones of Dyckman 386 is calling Mr. J. Desigante of Ciudad 762 in Buenos Aires. We shall assume now that Clairview and Lindhurst have the same functions as in the case described previously except that they are naturally provided with a much more powerful transmitter and a suitable receiving set. At Buenos Aires, the transmitting station is at the (assumed) town of Sol del Plata, and the receiver at the (assumed) town of Parina.

The wire line connections, line amplifiers, and auxiliary apparatus are like those at Clairview and Lindhurst. Speech from Mr. Jones to Mr. Desigante travels over the following route:

Mr. Jones at Dyckman 386—Dyckman central—(possible intermediate centrals not here considered)—Clairview—(by radio) Parina—(by wire) Sol del Plata—(possible intermediate centrals not here considered)—Ciudad central—Mr. Desigante at Ciudad 762.

Speech from Mr. Desigante to Mr. Jones travels as follows:

Mr. Desigante at Ciudad 762—Ciudad central—(possible intermediate centrals not here considered)—Sol del Plata—(by radio) Lindhurst—(by wire) Clairview (possible intermediate centrals not here consider) — Dyckman central — Mr. Jones at Dyckman 386.

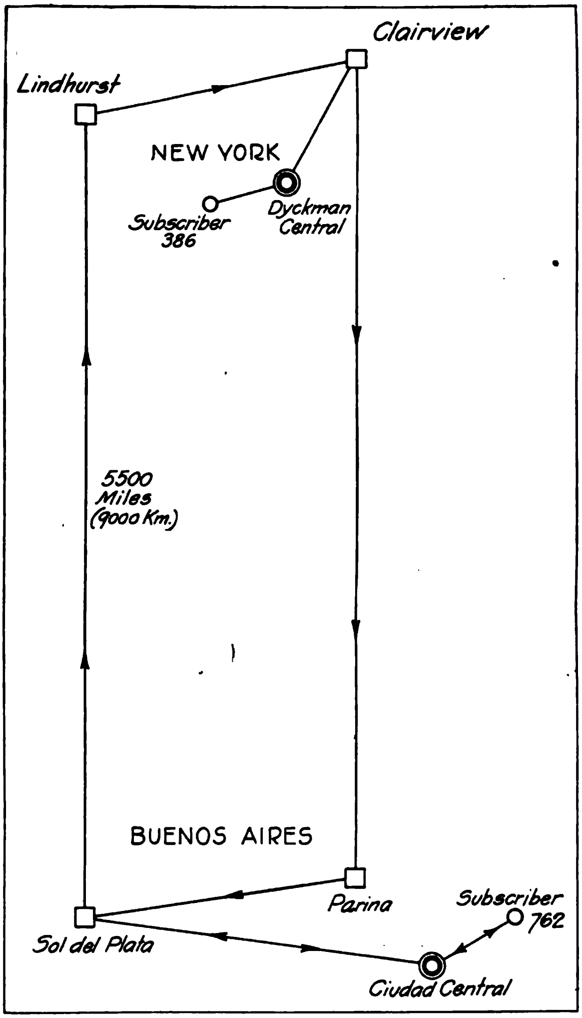


Figure 209—Typical duplex long distance radiophone system

These paths are shown clearly in Figure 209. The detailed dialogue between all parties involved is here given. In addition, before each remark we give the elapsed time *in minutes and seconds* very roughly estimated:

0.00—MR. JONES (on his wire telephone): Radio long distance, please.

0.05—OPERATOR (AT DYCKMAN CENTRAL): One minute, please. (She connects his line to the Clairview Radio Station line. The internal procedure at the central or centrals is here omitted.)

0.25—OPERATOR (AT CLAIRVIEW): Radio long distance speaking.

0.30—MR. JONES: I wish to speak to Buenos Aires. A particular person call for Mr. J. Desigante, D-e-s-i-g-a-n-t-e, whose number is Ciudad 762.

0.45—OPERATOR (AT CLAIRVIEW): Buenos Aires, Mr. J. Desigante, D-e-s-i-g-a-n-t-e, of Ciudad 762. What is your number?

1.00—MR. JONES: Dyckman 386, Mr. Frank Jones, the subscriber, speaking.

1.05—OPERATOR (AT CLAIRVIEW): Thank you. Hang your receiver on the hook. I will call you as soon as your connection is ready.

1.20—OPERATOR (AT CLAIRVIEW, talking out on the radiophone): Hello, Buenos Aires. Hello, Buenos Aires. Hello, Buenos Aires. New York, calling.

1.45—OPERATOR (AT SOL DEL PLATA, receiving through Parina): Hello, New York. Buenos Aires speaking.

1.50—OPERATOR (AT CLAIRVIEW): I want Ciudad 762, Mr. J. Desigante, D-e-s-i-g-a-n-t-e. Mr. Frank Jones calling.

2.15—OPERATOR (AT SOL DEL PLATA): Ciudad 762, Mr. J. Desigante, D-e-s-i-g-a-n-t-e. Mr. Frank Jones calling. Hold the air, please. (Speaking on the wire line) Hello, Ciudad. Sol del Plata calling.

2.35—OPERATOR (AT CIUDAD) (The internal procedure at the central or centrals is here omitted): Hello, Sol del Plata. Ciudad speaking.

2.40—OPERATOR (AT SOL DEL PLATA): Ciudad 762, please.

2.42—OPERATOR (AT CIUDAD): 762?

2.45—OPERATOR (AT SOL DEL PLATA): Yes, please.

2.55—Mr. DESIGANTE (on his wire telephone): Hello, this is Ciudad 762. Mr. J. Desigante speaking.

3.00—OPERATOR (AT SOL DEL PLATA): Mr. Frank Jones of New York wishes to speak to you. Hold the wire, please. (By radiophone): Hello, Clairview. Ciudad 762 is ready for you now.

3.20—OPERATOR (AT CLAIRVIEW): Thank you. Hold the air, please. (By wire telephone): Hello, Dyckman. Clairview calling. Give me 386 again, please.

3.30—OPERATOR (AT DYCKMAN): 386?

3.33—OPERATOR (AT CLAIRVIEW): Yes, please.

3:50—MR. JONES (on his wire telephone): Hello, this is Dyckman 386 Mr. Frank Jones speaking.

3.53—OPERATOR (AT CLAIRVIEW): Mr. Desigante is ready now Go ahead, please. (The operator at Clairview here closes the necessary amplifier circuits and takes a supervisory role only.)

3.56—MR. JONES: Hello, Mr. Desigante. Jones speaking.

4.00—MR. DESIGANTE: Hello, Mr. Jones. Desigante speaking.

4.01—MR. JONES: About that shipment number 1167 of April 18th on the "Curalo," I wanted to ask whether . . . . .

As stated before, the charges on such telephone service might well take account of the time of day and of the season of the year.

There will be an interesting competition between very high speed telegraphy (possibly with automatic recording *and transcribing* apparatus) and radio telephony in connection with the normal transaction of business. It is too early to venture any predictions regarding the results of such competition. However, for personal communications there can be no doubt as to which form of communication will be preferred.

(d) **FUTURE DEVELOPMENT OF RADIO TELEPHONY.** Now that the need for radio telephony is well recognized, we may confidently expect a very rapid development. Once a public demand is created, the technical advances required to satisfy that need must shortly follow.

Some interesting possibilities as to universal communication may be con-

sidered. As far as portable transmitters are concerned, it is unlikely that a man will be able for some time to come to carry a radiophone set capable of communicating more than a few miles. Some new motive force, the apparatus for producing which has a very small weight per kilowatt delivered, must first be discovered. So far as reception is concerned, however, very sensitive and light receiving apparatus, capable of receiving messages from hundreds (or even thousands) of miles is imaginable. So that it should become ultimately possible to keep in immediate touch with the traveling individual regardless of his motion or temporary location. A great field of usefulness is thus opened to development.

The linking of the wire telephone and radiophone systems of a country will go far toward making it possible for travelers to keep in touch with their homes and business at all times, and for the people of one nation to know the people of far distant nations in a close and intimate fashion. By the use of a deferred or night radiophone service (analogous to the day letter or night letter of the wire telegraph companies), reasonably inexpensive communication of this type should become feasible since such service might be rendered at times of light load and would tend to maintain the steady usefulness of the station. As is well known, stations are most efficiently operated when the load is nearly always full and constant. Plant efficiency requires, therefore, that some sort of premium be put on utilization of the plant facilities at times of normally light load.

In conclusion, it may be stated that it is certain that radio telephony, properly fostered by the Governments of the world, must become ever more useful to humanity. From ship and shore stations, from aeroplane and ground, from trains and depots, over forests and deserts, across oceans and continents will pass the spoken word of man. We may justly paraphrase President Elliot's splendid eulogy of another type of communication. His words apply with multiplied force to the radiophone of the future. We may rightly term this instrument for speeding the voice of man across space as:—

CARRIER OF NEWS AND KNOWLEDGE.
INSTRUMENT OF TRADE AND INDUSTRY.
PROTECTOR OF LIFE AT SEA.

MESSENGER OF SYMPATHY AND LOVE.
SERVANT OF PARTED FRIENDS.
CONSOLER OF THE LONELY.

BOND OF THE SCATTERED FAMILY.
ENLARGER OF THE COMMON LIFE.

PROMOTER OF MUTUAL ACQUAINTANCE.
OF PEACE AND GOOD WILL AMONG MEN AND NATIONS.

(THE END)

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Building and Erecting a Steel Aerial Mast

WIRELESS experimenters of limited means usually find the construction of a good aerial mast one of their greatest difficulties, both because of the cost and the mechanical problems encountered. The 110-foot steel mast described herewith was built and erected at a cost of less than $20, and any experimenter, with the proper amount of energy and the assistance of a few friends, can duplicate it at about the same cost. It must be admitted at the outset, however, that although inexpensive, the outlay of labor and patience will be considerable. Two of these masts, erected two years ago, have passed through several terrific windstorms without showing the least symptoms of instability; in fact, they are so substantial that a professional steeplejack did not hesitate to climb one for the purpose of scraping and painting it.

The accompanying drawings, figures 1, 2, 3, and 4, show the various stages of construction. Figure 1 is a detail of the sectional joints; figure 2, a cutaway portion of the topmast; figure 3, a detail of the base, and figure 4 the completed mast.

The first essential is the steel tubes which, in this case, are discarded boiler tubes. These can be procured at the junk yards in various sizes and conditions. They are seamless and comparatively light, weighing about 70 pounds to the 14-foot section, and can usually be bought for a cent a pound, or 70c. a section. The price has advanced somewhat in the last year, however. Fourteen-foot lengths of 3½-inch tubing are the most desirable. Avoid those which are heavily rusted; old boiler tubes are not rusty under the scales unless they have been exposed to the weather a long time.

The second essential is some heavy water pipe for connecting sleeves. A 20-foot section of discarded pipe, not too much corroded, is cut into seven sections of equal length. It is best to have this done in a plumbing shop. The charge is usually 90c. per hour. The boiler tubes should be taken to the same shop and the rough ends trimmed off at the same time. The ends of the sleeve section should be slightly reamed, so as to facilitate entering the tubes into the sleeves. If 3½-inch boiler tubes are used, the sleeve pipe should be 3½-inch water pipe, because boiler tubes are measured on the *outside* and water pipe on the *inside*.

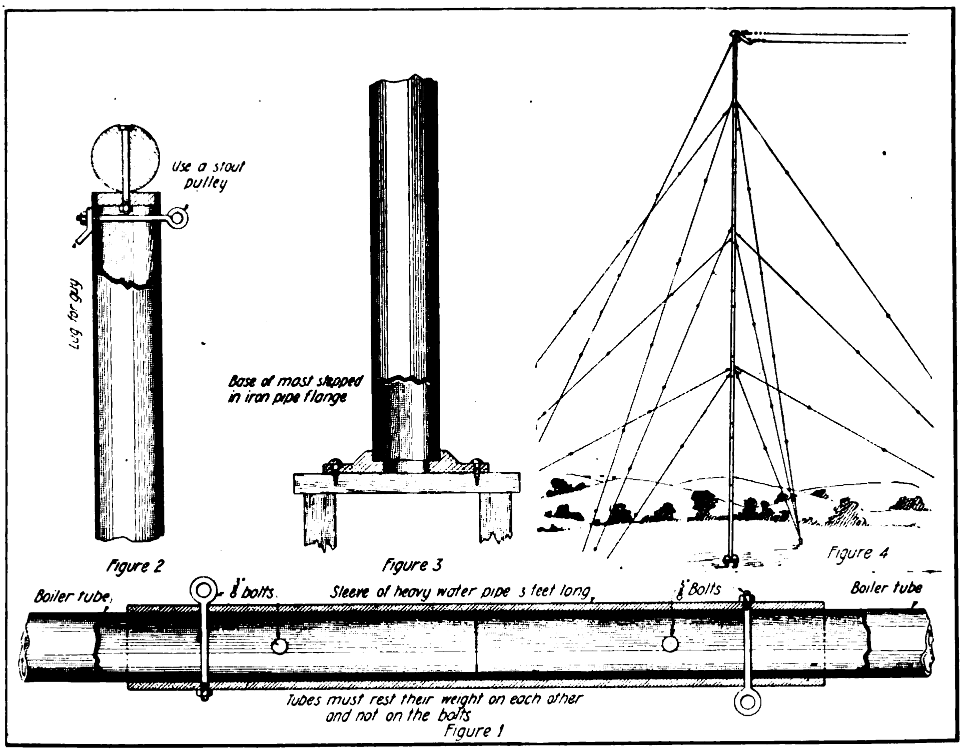
The accompanying diagrams show exactly how the sections are put together.

Probably the most important step is the fitting of the sleeves. It is absolutely essential, as will be readily seen, that the sections rest on each other so that the weight does not strain the bolts used in holding the sleeves in place. For this reason, it is best to fit on a sleeve and drill the holes for the bolts while the two sections are in place. Just how these sections are joined is shown in drawing, figure 1. One scheme is to lay the whole mast out on a level spot and drill the holes with an electric breast drill or ordinary breast drill. Or, if it is preferred to do the work indoors and a power drill is available, two sections can be fitted

at a time and drilled on a drill press by resting the sections on wooden horses. It is best to drill the holes a little larger than the bolts to be used, so that there will be no trouble in fitting the parts together when erecting the pole. In laying out these bolt holes, an effort should be made to keep them along the *same centre* line, so that when the pole is erected the holes are in two straight lines at right angles to each other. Another matter of importance is to mark carefully the relative positions of the sections and sleeves as they are drilled so that when the pole parts are assembled, no trouble will be experienced in making the holes line up. This marking can easily be done with a centre punch. Also be sure to number each section with a centre punch.

Large bolts are not necessary, as their only functions are to hold the sleeves in place and provide means for fastening the guy wires. Bolts ⅜-inch in diameter are sufficient. If eye-bolts are not available they can easily be made. One of these eye-bolts is used to hold the pulley for the aerial rope. It is a good precaution, when erecting a pole of this type, to put on two pulleys so that if anything happens to the aerial rope, another is available. A cheap rope can be used on the emergency pulley.

In fitting the sleeves for boring, it may be necessary to knock and scrape off some of the boiler scale on the tubes. After the holes are all bored, the sections can be laid on a couple of trestles and most of the scales knocked off with hammers. Next, with a couple of old square files, the remaining scale is scraped off and when the job is finished, the sections will be quite smooth. They should then be given a coat of asphaltum, which preserves the metal from the weather. Later, as the pole is being erected, cotton packing should be caulked into the upper joint formed by each sleeve and section, and a liberal coating of the asphaltum ap-



Figures 1, 2, 3, 4.—First prize article

plied to prevent water running between the tube and sleeve. It is well to give the pole another coat of asphaltum as it is being erected.

To give the top of the mast a nice finish, and at the same time to preserve it by keeping out the rain, a plug can be driven flush with the end and a wooden croquet ball fastened on with a long spike or bolt as shown in figure 2.

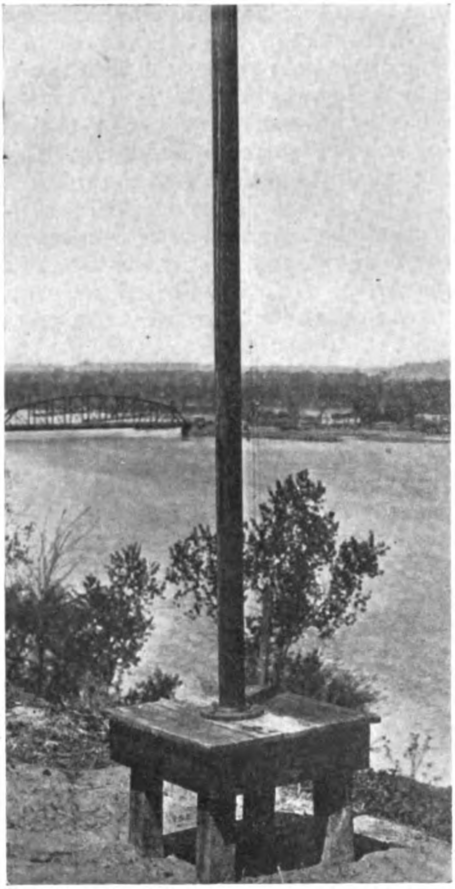
The final step in the preparation of the mast is to drill a hole for the eye bolt which holds the aerial pulley. The eye bolt in this case was made in the blacksmith shop and a galvanized iron pulley, suitable for 1/4-inch rope, was bought at a hardware store for 15 cents.

A small iron lug, to which a wire can be attached, is fastened under the nut on the bolt which holds the pulley. (See figure 2.) This makes it possible to attach a guy wire which acts as a direct brace against the pull of the antenna, if it is to be of the L or T type. A small iron device for holding the lower end of the rope, such as is used in fastening awning ropes on store fronts, is attached to the bottom section at a convenient height.

Raising the Mast

This is not as difficult as might be imagined, but it is a slow job unless plenty of help is available. It is presumed that the experimenter has picked out the location for his mast and has selected four trees or buildings to which the guy wires can be fastened. In our case we used three conveniently located trees and set one heavy post for the fourth guy pole.

From a friendly telephone or electric light plant manager, borrow a twenty-five or thirty foot pole. Set the pole in a hole four or five feet deep. This is to be used as a gin-pole in raising the mast sections. Setting this pole is quite a task and rather dangerous. It is best to borrow three or four pike poles such as linemen use, and with the aid of these the pole can be safely raised to a vertical position and slid into the hole. Four strong guy wires or ropes are fastened to the top of this pole and attached to heavy stakes driven well into solid ground. If a good ladder is not available, wooden cleats should be spiked to the gin-pole to facilitate getting up and down.



Mast described in first prize article

Near the top of the wooden pole a heavy rope is looped and securely fastened. This provides a loop in which to hook the hoisting device. For this purpose a good one-ton chain hoist with a long chain is desirable and can usually be borrowed. If it is of large size and long reach, so much the better, for the completed mast weighs about 700 pounds and a clearance of 15 feet must be provided to permit sections to be inserted. If the hoist is a short one, the mast can be raised as far as it permits, then securely blocked from below, and a new hold taken lower down.

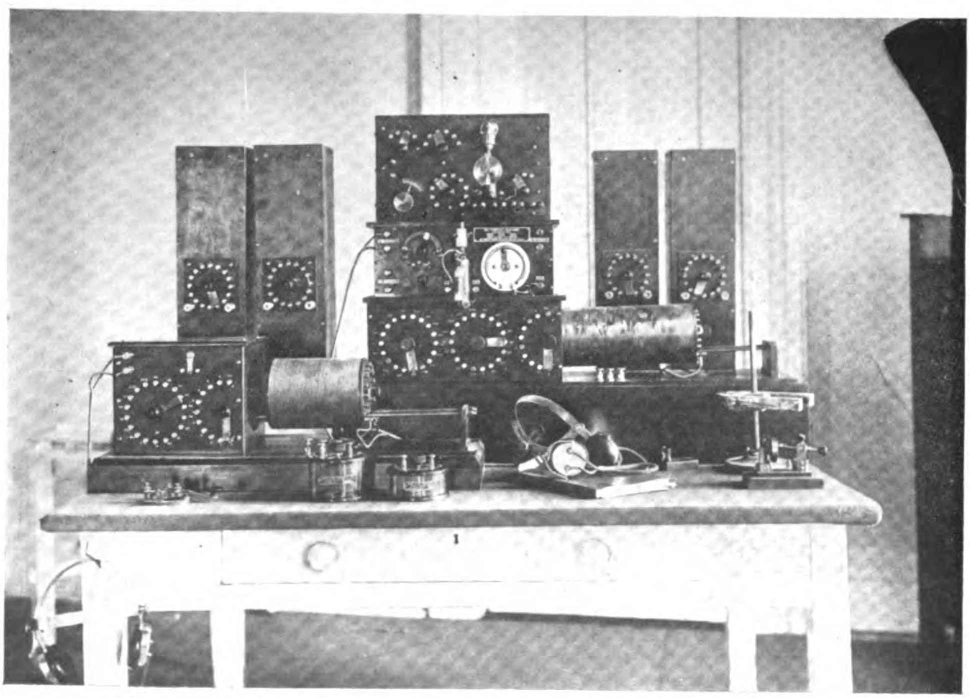
Before starting hoisting operations, the guy wires should be cut into sec-

tions and insulators attached. If No. 8 or No. 10 galvanized wire is used, three sets of guy wires will support the pole. The wire should be cut into 40 or 50-foot sections and a good porcelain knob insulator attached to one end of each wire. Thus it is possible to lengthen the guys, as the mast is raised, by simply adding on sections of wire. The insulators can be procured for two cents each. The kind with the groove in the center is preferable.

When the hoist is in position, bolt sections No. 1 and No. 2 together with the base of section 2 at the foot of the gin-pole. Then it will be necessary to thread the aerial rope through the pulley. It is safest to tie the loose ends of the rope together and coil the rope in a bucket so that it will uncoil easily without tangling as the mast is raised. After the rope is in place, a section of guy wire is fastened to the lug on the pulley bolt. This guy wire is used as explained previously to take the strain of the aerial off the top section of the mast.

By means of the chain hoist or a block and tackle, the two united sections are then raised upright alongside the gin-pole and lashed safe with rope. Now caulk the top joint of the sleeve and run in a little asphaltum. Next fasten guy wires to the four lugs on the sleeve. It now becomes necessary to raise this portion of the mast 15 feet before another section can be added. It is a simple matter to take a hitch around the lower end of the tubing and hoist it, but it must be kept vertical by allowing it to slip through lashings of stout rope at the top of the gin-pole and at the base of the mast sections. When it is raised sufficiently, the third section, which has been equipped with its sleeve meanwhile, is placed in position and bolted.

Before raising the mast further, means must be provided for keeping it perpendicular as it is raised. If there is plenty of help, a man at each guy wire, with a hitch around a post, can hold it; if not, the four wires must be loosened a little each time the mast is



Station of first prize winner

raised 2 feet. This necessitates many trips to the guy posts and takes a lot of time.

Care must be exercised all the time, that the sleeve joints are well caulked and that the rope to the pulley runs free. It is also important that the base of the ascending mast be kept fastened to the gin-pole with a sliding rope noose; otherwise it would be likely to veer sideways. And don't stand directly under the mast. Let the man at the chain hoist keep his eyes and ears open and be prepared to jump if anything breaks. If care is exercised, no accidents need happen.

Guy wires need only be fastened at every other joint, but sometimes it is best to guy the two uppermost joints and then every other joint after that. As a base for the mast, a small platform built over four stout posts set in the ground close to the gin-pole should be provided as shown in figure 3. This should be framed heavy enough to carry the weight of the pole. The top should be watertight and an apron dropped around the platform to a depth of 6 inches, to insure several inches of the supporting post remaining dry in the stormiest weather. As this is built close to the gin-pole, it is easy to set the completed mast on it. A heavy block with a 3½-inch hole bored in for a depth of 1 inch, makes a good base in which to set the mast. This block is then spiked to the platform.

The last step is to guy the pole perfectly perpendicular. Iron turnbuckles can be used but are not absolutely necessary.

In the event that one of these masts is to be erected on a barn or other two-story building the operation is quite simple. It is only necessary to cut a hole in the roof and in the hayloft floor, and by using the chain hoist the sections can be spliced together and pushed up through the roof. In this case, the base of the pole when completed rests on the upper floor of the building.

The following table gives the material required and the approximate cost:

8 lengths 14-ft. boiler tubing 3½ in. diameter at 1c a lb.	$5.60
20 ft. 3½ in. heavy water pipe	1.50
13 eye bolts 3/9 in. x 4½ in.	.55
16 bolts ⅜ in. x 4½ in.	.35
Having pipe cut and tubes trimmed (2 hrs. at 90c)	1.80
Pulley	.25
Rope—115 feet ¼ in. Manilla	.90
Paint, one quart	.75
Insulators, 100 at 2c each	2.00
Guy wire, 150 lbs. at $4.00 per C	6.00

I may add, in conclusion, that practically all of my apparatus is home-made from ideas found in THE WIRELESS AGE. Take, for example, the receiving apparatus shown in the photograph. It comprises long and short wave receiving tuners and a vacuum valve amplifier, with complete circuits for the reception of damped and undamped oscillations. With it, I can hear stations thousands of miles off. These results were made possible by the advice given to the experimenter from time to time through the columns of your valuable publication.

FRED W. JAMESON, *Kansas*.

SECOND PRIZE, FIVE DOLLARS

A Serviceable Switchboard for the Experimenter's Laboratory

IN the electrical laboratory or wireless operating room it is often desirable to have some form of a switchboard to facilitate the mounting and handling of experimental apparatus. Figure 1 shows the details of construction for a simple yet substantial board that can be easily built without machine work or special tools. The board may be of marble, slate, or any good insulating material such as bakelite. A large board should be made up of several sections or panels, as the small sections are easier to handle and mount, and are less liable to crack when boring the holes. The standards should be made of one iron pipe and standard pipe fitting.

The panels, *C* figure 1, are first bored to receive the bolts that hold it to the pipe standard. After this the holes for the various switches or instruments should be bored. In the event that marble is used, a steel drill should be employed and water allowed to drip on it constantly during the operation. This will prevent both the board and

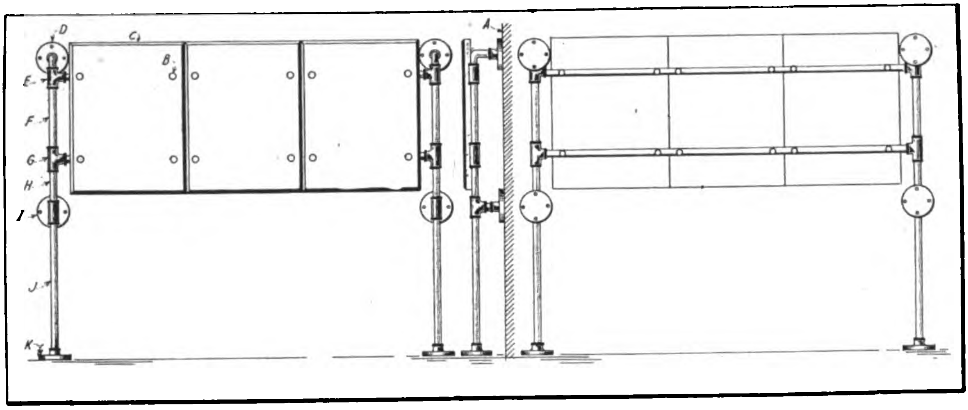


Figure 1—Second prize

the drill from breaking. Care should be taken to drill the holes very slowly. Each panel should be completely bored ready to mount before building the standards.

As shown in the accompanying drawing, the board is supported by two upright pipes; the panels are supported on two horizontal pipes by machine bolts *B;* two additional horizontal pieces are employed to fasten the board against the wall *A*.

Referring again to the drawing, a deck flange *K,* screwed to the floor, holds the upright firmly in position. A section of pipe *J* ends in a T-fitting *I,* which in turn connects with another deck flange bolted to the wall. This is clearly indicated in the side view of the drawing. The spacing in the rear will be governed by the builder's requirements. Continuing from the upright section, another section of pipe *H* terminates in a T-connection *G,* which holds one end of a horizontal length to which the lower end of the board is attached. The horizontal lengths of pipe are in one piece with a T-connection on each end.

Another short length of pipe *F* terminates in a T-fitting *E* which holds the upper deck flange *D,* the latter is screwed to the wall and also the upper horizontal length of pipe to which the panels are bolted. The upright at the other end of the board is built up in the same manner. As each panel is bolted in four places to the pipe standard, and the standard in turn screwed to the floor and back wall, the entire structure forms a strong, substantial and well appearing switchboard with plenty of room on the face, and capable of carrying considerable weight. If the pipe standards are connected to earth there will be no trouble from induction or static electricity.

R. H. Foster, *Florida.*

An Instrument for Daily Code Practice

It would be well for amateurs to engage in daily code practice during this period to keep up to the mark. A satisfactory instrument for this purpose is the one described here which can be made for a few cents. The only material required is: An old alarm clock, a test buzzer (an old, ordinary bell buzzer will do) two binding posts, some sheet brass, tin or copper, and a discarded cigar box.

First, the paper is taken from the box and then the clock is taken apart, that is, the case, hands, dial, are removed. The works are then set in the box and if of the correct dimensions, the shaft will protrude about half an inch. A place is marked in the corner, and a hole bored so that the shaft will have the position shown in Figure 1. Next, the clockwork is screwed to the bottom of the cigar box. The buzzer is then mounted about 1 inch from the clockwork, the binding posts being placed at the right hand end of the box. Figure 1 shows the necessary details. The omnigraph is now complete except for the record and brush.

The record can be easily made. There are, I might say, two methods of con-

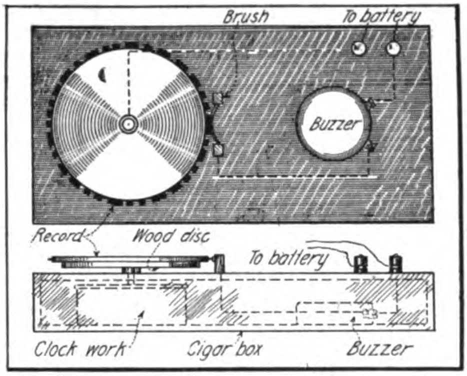


Figure 1

struction. The first is to take a sheet of copper, or tin or some other metal that carries electricity well, about 1-32 of an inch in thickness and cut the dots and dashes as shown in Figure 1. Sheet brass is the best. Describe a circle 4½ inches in diameter with a compass. Next, cut the code characters you wish to learn or practice. The successive letters must be evenly spaced. Then describe a circle 4 inches in diameter on a piece of cigar box wood and cut it out with a compass saw. Then bore a hole that will fit tightly over the shaft of the clockwork. The disc is now ready for mounting. First force the wooden disc, about half-way down, which ought to leave about 3-16 of an inch between the record and the cigar box. Then force on the record (after punching a hole just a trifle smaller than the shaft of the clockwork). The last thing in the order of construction, is to mount the brush. The disc may be laminated, in fact it ought to be ½ inch in thickness. This will form a more positive contact with the brush which should be adjusted so as to touch only

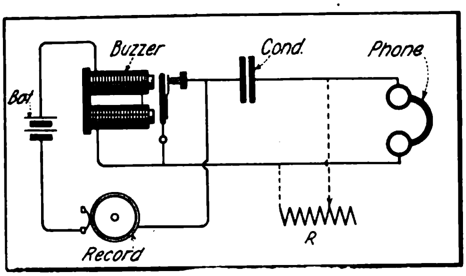


Figure 2

one dash or dot at a time. The records for this machine may be purchased, if the constructor so desires. The wiring diagram is given in Figure 2.

MAURICE STEPHEN MIRANDA,
New York.

Changing a Low Voltage Buzzer to Operate on 110 Volts

An ordinary low voltage buzzer may be easily changed over to operate on 110 volts, but it must be remembered that the moment a buzzer is operated on this voltage its entire wiring must be installed to conform with the rules under Class C, National Electrical Code, exactly like any other interior light or power wiring.

The modification in the buzzer required is this: Shift the position of the contact spring so that it touches the back of the fixed point when the armature approaches the magnet pole, instead of the usual break. If necessary, change the coil contacts so that the action of the vibrator is to short circuit the coil instead of opening the circuit.

Then put the buzzer in series with a 25-watt Tungsten lamp (better than a carbon on account of the temperature coefficient of the metal), using standard B. & S. No. 4 R. C. wire on porcelain insulators for connections. If you do not take this precaution you will have trouble with the local electrical inspection department, municipal or insurance bureau.

W. L. S., *Massachusetts.*

Use of Radio by German Raiders

Officers of German war vessels cruising along the Pacific Coast erected a wireless station on Easter Island late in the year 1914, and because of the remoteness of this island from the outside world the apparatus was undetected for a number of months. It was employed for keeping in touch with the movements of their vessels. It is understood that this station and apparatus have been confiscated by the Chilean authorities.

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION
Founded to promote the best interests of radio communication among wireless amateurs in America

A Model Amateur Station

Members of the Association who have owned long distance amateur stations and who at one time or another have entered into the great trans-continental relay contests, will recall with much enthusiasm the signals of station 2 PM. This record-breaking apparatus was owned and formerly operated by A. J. Faraon and J. F. Grinan of New York City. Investigation reveals that the efficiency of this station is accounted for by the fact that it was not constructed on a "hit or miss" principle, but it represented a co-ordination of the latest and best in the amateur field at that date.

Not only have the owners of 2 PM broken all long distance records in amateur wireless telegraphy, but they have been able to communicate with amateur stations almost throughout the United States. They have also operated 2 PM as a relay for messages originating in the New England States.

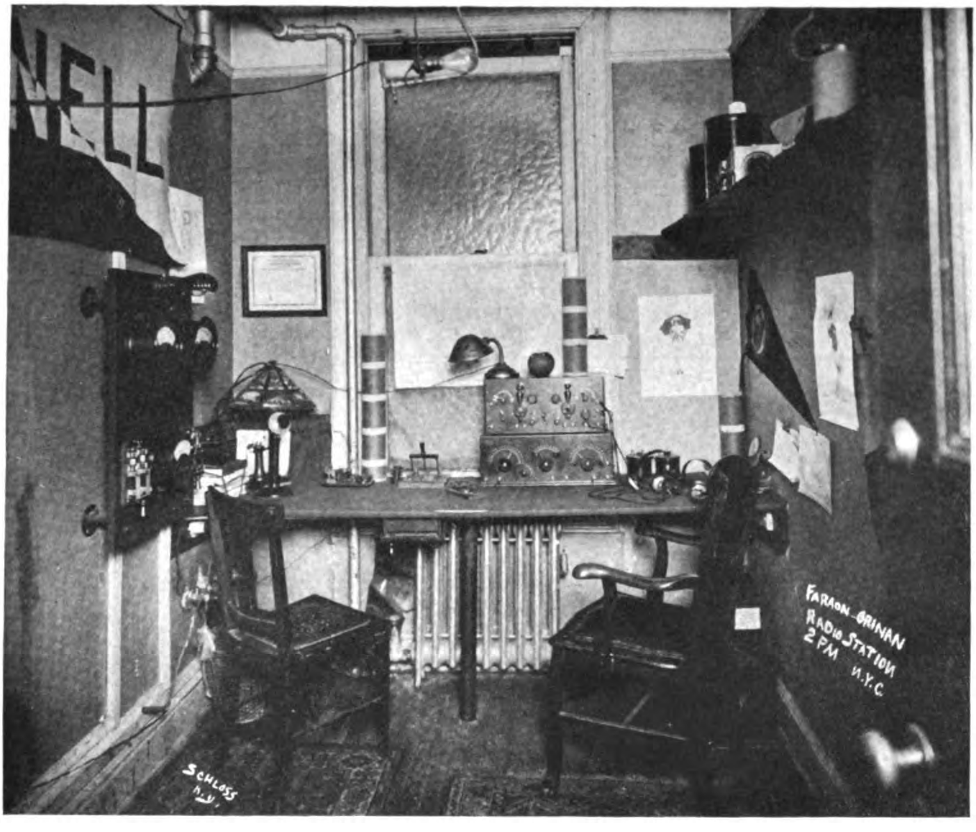
The antenna of 2 PM consists of two wires, spread forty feet apart, stretched from two water tanks on the roof of a twelve-story apartment house across West End Avenue to two tanks on top of another apartment house. Insulators are placed three-quarters of the way across the street, thus reducing the natural period of the antenna to 184 meters. The wires are made up of fifty strands of No. 34 enamelled magnet wire.

As shown in figure 1, the transmitting apparatus consists of a 1 kw. Northern Electric motor-generator, a 1 kw. open core transformer, ten copper-coated leyden jars and the so-called

Figure 1—The 1 kw. transmitting set known to all amateurs as 2 PM

Blitzen oscillation transformer. A synchronous rotary spark gap is mounted on the coupling between the motor and the generator and is enclosed in a muffling box. A hot wire ammeter is also connected in series with the earth lead, as shown at the right of the photograph.

With this apparatus, the antenna meter registers a current of 2.6 amperes on the wave-length of 200 meters, the decrement of the oscillations being .09.



Complete view of the station which started the record-breaking relay

The power input is 450 watts—well within the United States regulations.

The receiving set consists of a Paragon regenerative coupler with a one-step amplifier.

Messrs. Grinan and Faraon have communicated with stations as far West as Denver, Colo., with their equipment. Station 9 ZF has repeatedly been communicated with. Their signals were also heard in Los Angeles, Cal., by J. B. Farrington. A. F. Pendleton, who recently made a trip on the s. s. Manchuria, reports their signals, Q S A, 2,100 miles east of Nantucket.

2 PM, as stated in the June issue of THE WIRELESS AGE, was the starting point for the record-breaking transcontinental message. This station gave its direct O. K. to 9 ZF in Denver, who said that its signals were strong throughout the evening. The signals from 9 ZF were also easily readable in New York City at the same time, and since this preliminary test these two stations have repeatedly communicated with each other.

Outside of the second district, station 2 PM worked with twenty-seven stations in the eighth district, thirty-two stations in the ninth district, seven stations in the first district and eleven in the third district. This was accomplished during February and March,

(*Continued on page* 525)

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

R. W., Portsmouth, Ohio:

The amplification you may expect from the cascade amplifier such as is described in the book, "How to Conduct a Radio Club," depends largely upon the type of vacuum valve bulb you employ. Also take into consideration that although this apparatus was designed to amplify audio frequencies, there is some amplification of the radio frequencies; therefore the amplification to be expected will depend largely upon the part played by either current.

No harm will result from placing this amplifying coil near the other parts of equipment nor will you experience any losses by the use of telephone jack switches for changing connections from one circuit to the other.

* * *

F. D., San Francisco, Cal., inquires:

Ques.—(1) Please publish in The Wireless Age a wiring diagram for a regenerative receiver employing a three-

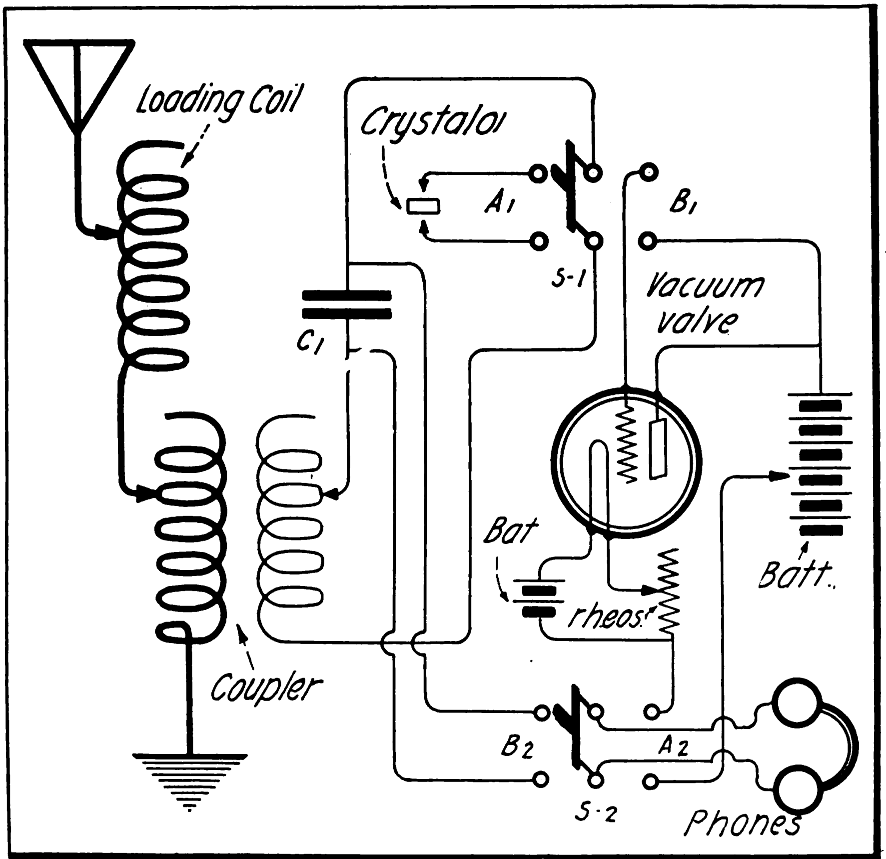


Figure 1

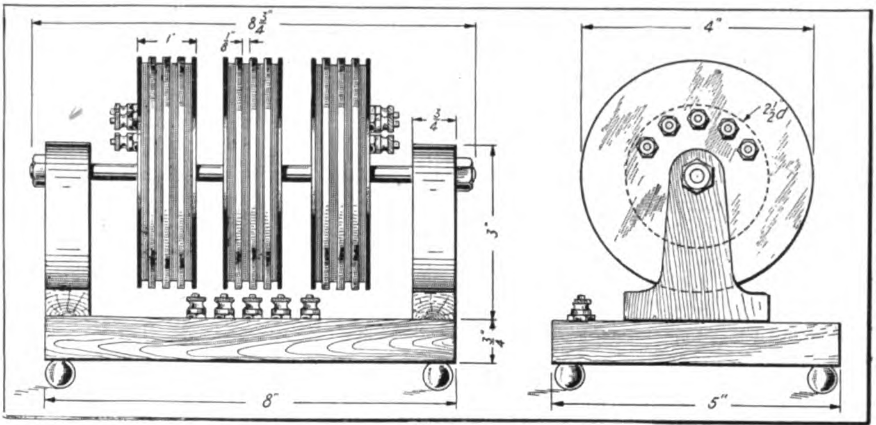


Figure 2

electrode vacuum valve and the following additional apparatus: a loading coil, coupler with a variable secondary and primary; a secondary variable condenser of .0004 microfarad. If possible, arrange this circuit so as to include a crystaloi detector for alternate use with the vacuum valve. I should like, if possible, to have this change take place by the operation of one double-pole, double-throw switch.

Ans.—(1) A complete diagram of connections for a regenerative circuit is shown in figure 1, also the connections and switch arrangements for the crystaloi detector. It will not be possible to make the necessary changes by a single, double-pole, double-throw switch because the telephones in the vacuum valve circuit are connected differently in the crystaloi circuit. The switching arrangements for changing from one detector to the other are shown at S-1 and S-2. When the switch, S-2, is thrown to the position, A-2, and the switch, S-1, to the position, B-1, the vacuum valve is connected ready for use, and if both switches are thrown in the opposite direction, the crystaloi detector will be connected in series with the secondary winding, and the telephones will be shunted around the grid condenser, B-1. The crystaloi detector requires a rather large value of capacity at C-1, and, therefore, you may obtain increased strength of signals by placing a small fixed condenser of .01 microfarad in shunt to the condenser, C-1, which usually is one of very small capacity for use with the valve. By slight re-arrangements of these connections, you can construct a four-blade, double-throw switch by means of which all the connections can be shifted simultaneously with one operating handle. For longer wave-lengths, increased strength of signals will be obtained with the regenerative circuit by placing a variable condenser in shunt to the battery and head telephone.

Ques.—(2) What would be the possible wave-length adjustment of a tuner, the primary of which is wound with No. 26 S. S. C. wire on a tube 4 inches in diameter, the winding being 4 7-8 inches in length. The secondary winding is 3 1-2 inches in diameter, 5 7-8 inches in length wound with No. 29 S. S. C. wire. This is to be used with a two-wire aerial, 30 feet above the earth and 200 feet in length. The secondary capacity will be variable up to .0004 microfarad.

Ans.—(2) This receiving set will respond to waves of about 3,200 meters in length.

Ques.—(3) Some day I will construct a regenerative short wave receiving set such as described in the April, 1917 issue of your magazine, but I do not wish to vary the coupling between the primary and secondary by the method suggested by that writer. Is there any other way by which I can vary the coupling?

Ans.—(3) You could mount the secondary winding on a sliding rod, and have a knob extend through the side of the case by which the secondary coil could be drawn in and out of the primary winding.

Ques.—(4) Kindly give me the dimensions of a receiving tuner that will respond to wave-lengths up to 15,000 or 20,000 meters with a .001 microfarad condenser connected across the primary, and one of practically the same capacity connected across the secondary winding.

Ans.—(4) If you constructed a long wave receiving tuner using single-layered windings for both the primary and secondary, you would require two tubes from 20 to 25 inches in length, and from 5 to 6 inches in diameter, the actual dimensions, of course, depending upon the size of the wire with which the coupler is to be wound. It is customary nowadays to use multi-layered windings because they give the required amount of inductance with a minimum amount of ohmic resistance. A multi-layered tuner was described on page 677 of the June, 1917, issue of THE

(*Continued on page* 524)

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(*Continued from page* 515)

Wireless Age, but the dimensions were not quite complete. This tuner was designed by F. N. Tompkins of Providence, R. I., and has given very good results on long distance reception. In order that you may have a complete set of dimensions, we publish (figure 2) a detailed plan of construction showing the exact dimensions throughout. If, after noting these, you will refer to the article in the June issue of the Wireless Age, you will have no difficulty in constructing the tuner.

If the primary and secondary windings of this receiving tuner are single-layered coils,, wound with No. 24 and No. 32 S. S. C. wire, respectively, you can obtain an approximate adjustment of 15,000 meters with the coupler described as follows: The primary winding should be 13 inches in length, 7 1-2 inches in diameter, wound closely with No. 24 S. S. C. wire. The secondary winding should be 12 inches in length, 6⅛ inches in diameter, wound closely with No. 32 S. S. C. wire. If a .001 microfarad condenser is connected in shunt to the primary and secondary windings the tuner will respond to 15,000 meters.

Cardboard can be protected from moisture by soaking in hot paraffine.

* * *

H. S. M. C. C., Newark, N. J., inquires:

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Ans.—(1) Multi-layered tuning coils are gradually being adopted for all types of receiving tuners. It is customary in the small sizes to wind the primary and secondary with two layers of wire, taps being brought out at convenient points for the desired range of wave-length. The advantage of these windings lies in the fact that a given amount of inductance is obtained with less ohmic resistance than in the case of the ordinary single-layered winding. When the coils are short and of large diameter, it is customary to wind the layers closely. Sometimes they are separated by a thin sheet of paraffine paper, but if the coil is long and of small diameter and is to be employed for long wave-length tuning circuits, it consists of three or four layers mounted concentrically with an air space of ¼ of an inch to ⅜ of an inch between layers. Just what is meant by a staggered winding is shown in figure 3, where 1, 2, 3, 4, etc., show the method by which the turns of a coil are staggered. This method of winding minimizes the distributed capacity between adjacent turns and is therefore often employed.

* * *

L. L. Z., Saginaw, Mich.:

The chemical formula for chalcopyrites, commonly known as copper iron sulphide, is $Cu_2\,SFe_2\,S_3$. In the original perkion detector, zincite and chalcopyrite were used, but in the modern perikon detector zincite and bornite are employed as the rectifying elements.

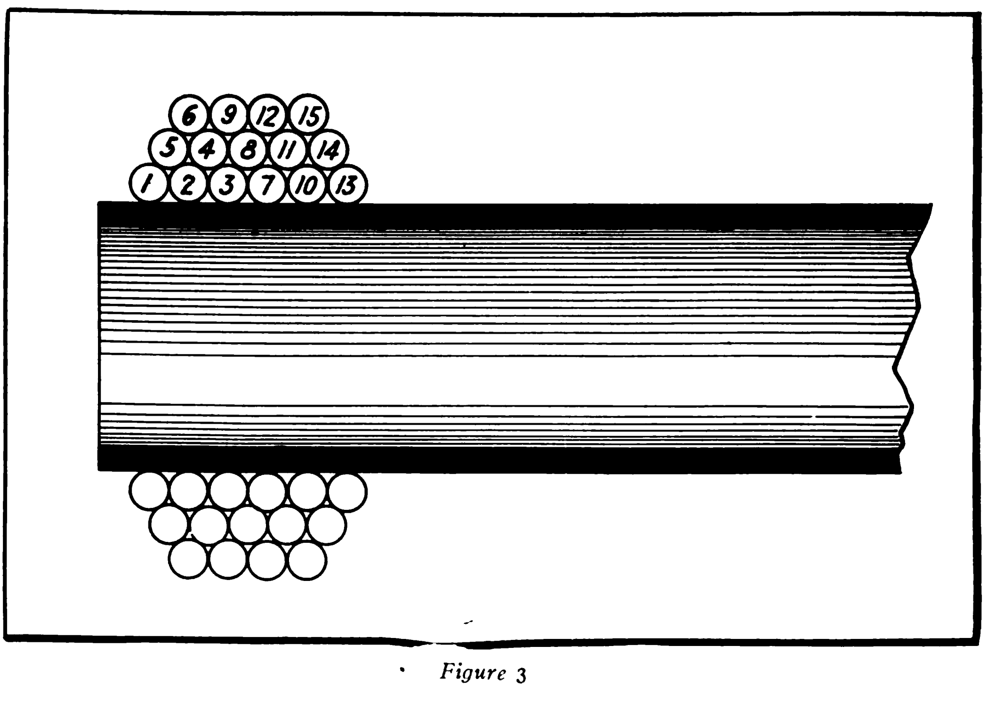

Figure 3

A. R. L., Bloomington, Ill.:

It is our understanding that the Telefunken Company employed a piece of graphite in contact with a crystal of galena as their oscillation detector. It is asserted by some that this type of contact possesses greater stability than the ordinary cat whisker. Our experiences along this line do not indicate increased sensitiveness, but under certain operating conditions it seemed much easier to find a sensitive contact point with a piece of graphite than with a piece of steel. It is doubtful, however, whether our observations would hold good under all conditions and circumstances.

As we have mentioned time and time again in this department, commercial wireless telegraph companies have found the carborundum crystal to be the most dependable of all the crystal rectifiers.

We have no doubt that the Navy would be able to utilize your services. Young men of the proper physical qualifications having first class knowledge of radio engineering would undoubtedly be of great help to the Government. We advise you to communicate with the Commandant at the Mare Island Navy Yard, San Francisco, Cal.

N. A. W. A. Bulletin

(*Continued from page* 513)

1917. During this period the stations handled a total of 654 messages, most of them transmitting over distances of 1,000 miles.

The success attained in long distance communication by these experimenters is accounted for by the fact that their set is well balanced throughout, no pains having been spared to obtain the best apparatus. The set was installed to reduce energy losses to a minimum and also to comply strictly with the law. This is in striking contrast to some amateur stations wherein basic principles have been ignored and any apparatus which would make a spark has been installed.

Faulty Transmitters

One reason why certain amateur transmitters have proved inefficient is due to the fact that a considerable amount of transformer arc is present in the spark discharge, and on account of this it is necessary to use a very loose degree of coupling between the primary and secondary windings of the oscilla-

tion transformer in order to prevent the reaction of the antenna circuit upon the spark gap circuit. All high voltage transformers for radio work should have a certain amount of magnetic leakage and should draw no more current on short circuit than under normal operating conditions. This will tend to prevent arcing at the spark gap and therefore will assist in quenching out the primary oscillations. A much closer coupling, therefore, can be employed between the primary and secondary without reaction between the two circuits and with increased antenna current.

The use of an abnormal spark discharge gap is in all cases to be avoided, as generally the best results are obtained from the plain gap by separation of the electrodes to a distance of no more than ¼th or ⅜ths of an inch. With any spark gap there is a length which gives the minimum of resistance, and generally this is the condition sought for. Extremely short gaps tend to assist the quenching of the oscillations, but the purity of the note is destroyed and a very low degree of efficiency thereby obtained. Of course, this can be eliminated by putting a number of discharge gaps in series, as is done with the multiple plate or series spark discharger.

Modulation of Antenna Current in Wireless Telephony

It is not generally known by experimenters at large that the apparatus employed in the Arlington, Paris and Honolulu wireless telephone sets was so designed that when the transmitter was spoken into a variation of antenna current was secured almost equal to that obtained by opening and closing a telegraph key. This, coupled with the sensitiveness of the receiver employed, accounted for the fact that the voice could be carried over such extremely great distances.

At the receiving station in Honolulu, six three-electrode vacuum valves were employed in cascade for detection of the signals. Great care had to be taken in mounting the apparatus away from

metallic objects, otherwise the valves would "sing" at audio-frequencies and thereby produce interfering sounds. The sensitiveness of this receiving apparatus was such that time signals from Arlington could be heard at Honolulu with the receiver several feet from the observer's ears.

Book Review

Radio Communication. By John Mills. Soft leather binding; 5 x 7½ inches; 208 pages; McGraw-Hill, New York. Price $1.75 net.

In the preparation of this volume, the author has evidently taken into consideration the necessity for instruction in the fundamentals of the art, and in consequence the volume is in the main devoted to theoretical principles.

The book will be found suitable for students in engineering colleges who desire simple mathematical explanations of the fundamental facts surrounding the audio frequency and radio frequency currents.

The material for this book was primarily prepared for a company of the U. S. Signal Corps organized at the Western Electric Company.

The rear pages of the book are devoted to problems of wire and wireless circuits, and in order to aid the beginner in their solution complete answers are given; in some cases the problem is worked out through all its steps.

Obtainable through the Book Dept., The Wireless Age.

Acquiring Wings. By William B. Stout. Cloth binding; 5 x 7¼ inches; 57 pages. Moffat, Yard & Co., New York. Price 75 cents net.

The author of this book compiled its contents originally for the information of a group of civilians sent abroad by the Government. It therefore deals solely with basic principles of aviation in language which the layman can easily understand.

The little volume will find its main usefulness as an introduction to the art of air navigation.

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Learning to Fly in the U. S. Army. By E. N. Fales. Imitation leather binding; 5 x 7¼ inches; 180 pages. McGraw-Hill, New York. Price $1.50 net.

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About one-half of the volume is devoted to chapters on rigging, serving as a valuable reference text for the men whose training period is necessarily short under emergency conditions. So practical is the form of this material it is to be regretted that the author

did not include a chapter or two on airplane motors. The book is conveniently arranged and well illustrated.

Obtainable through the Book Dept., The Wireless Age.

The Aeroplane Speaks. By Capt. H. Barber. Cloth binding; 6¼ x 10 inches; 144 pages; 124 illustrations. Robert M. McBride, New York. Price $3.00.

Distinctive and valuable is the arrangement of the text of this British author, a prologue introducing the reader to the considerations which govern design for flight efficiency. Characters designated the Surface, the Angle of Incidence, the Re-action, etc., engage in a general discussion of their relative merits and value, which brings out their interlocking functions in a way to fix them in the student's memory.

Captain Barber gets down to the business of instructing immediately following the prologue, and crams full of information 71 pages on the subjects of flight, stability and control, rigging, propellers and maintenance. At no point is the book weighty in expression, although some features of design are explained at gratifying length to the novice. The aeronautical engine is omitted, but a valuable series of illustrations show the progress of aircraft construction chronologically.

This work is a very practical one and of special value as a beginning for the aviator who seeks a good knowledge of fundamentals.

Obtainable through the Book Dept., The Wireless Age.

Aircraft in Warfare. By F. W. Lanchester. Cloth binding; 6¼ x 10 inches; 222 pages. D. Appleton & Co., New York. Price $4.00 net.

As a text for military men who seek a broad understanding of the employment and value of aircraft in war, this volume easily reaches first place on the list. Mr. Lanchester, a member of Great Britain's Advisory Committee for Aeronautics, has been for some years a specialist on air fighting; he considers in this work the relations between aeronautic science and military art. He discloses what is termed the **N-square** law, a scientific statement of concentration of forces which Maj. Gen. Sir David Henderson characterizes "a most valuable contribution to the art of war."

Officers of the Signal Corps and Naval air forces will find this volume an invaluable treatise on the new art of war, worthy of careful study and a desirable addition to the libraries of those who are assuming new and greater military responsibilities.

Obtainable through the Book Dept., The Wireless Age.

Aviation Engines. By Lieut. Victor W. Page, U. S. R. Cloth binding; 5½ x 8½ inches; 571 pages. Norman W. Henley, New York. Price $3.00 net.

Equipped by past experience gained in the preparation of automobile engine text, Lieut. Page has made a carefully prepared and exhaustive volume on the subject of aeronautical motors. The thoroughness with which instructions on engine repairs and "trouble-shooting" have been laid down makes this work of very practical value to aviators and mechanics engaged in operating and caring for the internal combustion engines of the flying branches of military service. The illustrations are a material contribution to easy understanding of the subject, and the evident care exercised in compiling engineering information on many types of engines is a special recommendation for this needed work.

Obtainable through the Book Dept., The Wireless Age.

The Elements of Navigation. By W. J. Henderson. Cloth binding; 4 x 6¼ inches; 234 pages. Harpers, New York. Price $1.25 net.

Originally prepared for naval militiamen and yachtsmen, this little book has been changed and enlarged in the new edition to include information of particular value to men serving on coast patrol boats. In compact form all essentials of navigation are given, with due consideration to the special conditions of wartime.

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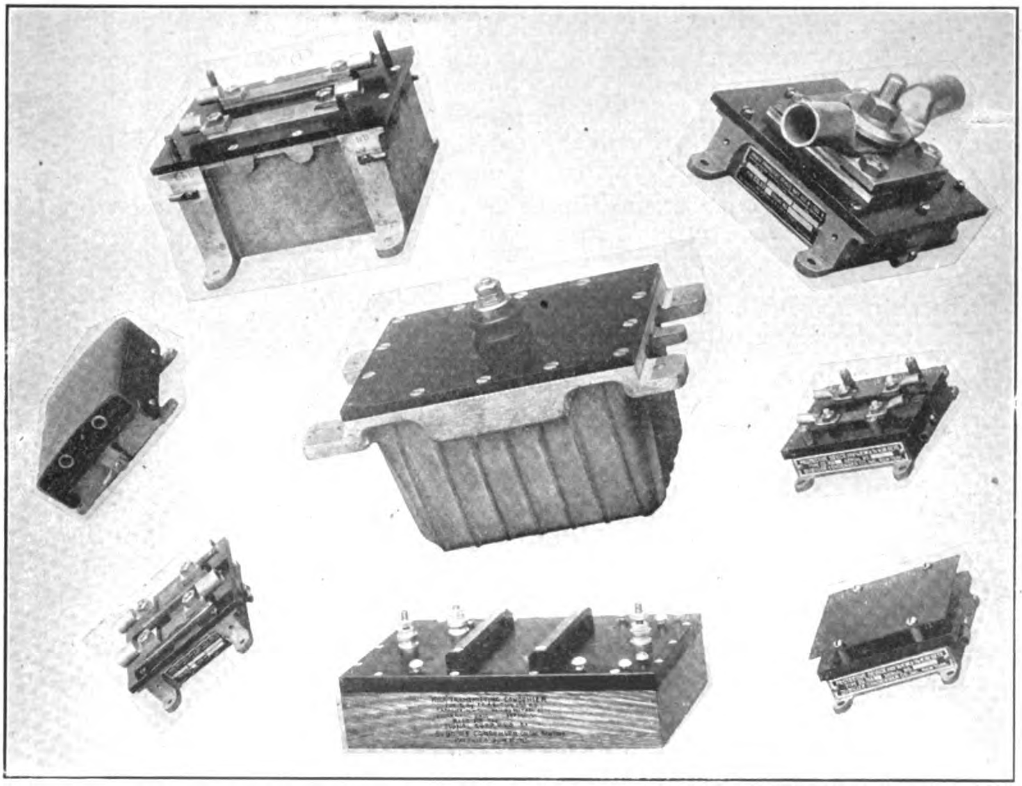

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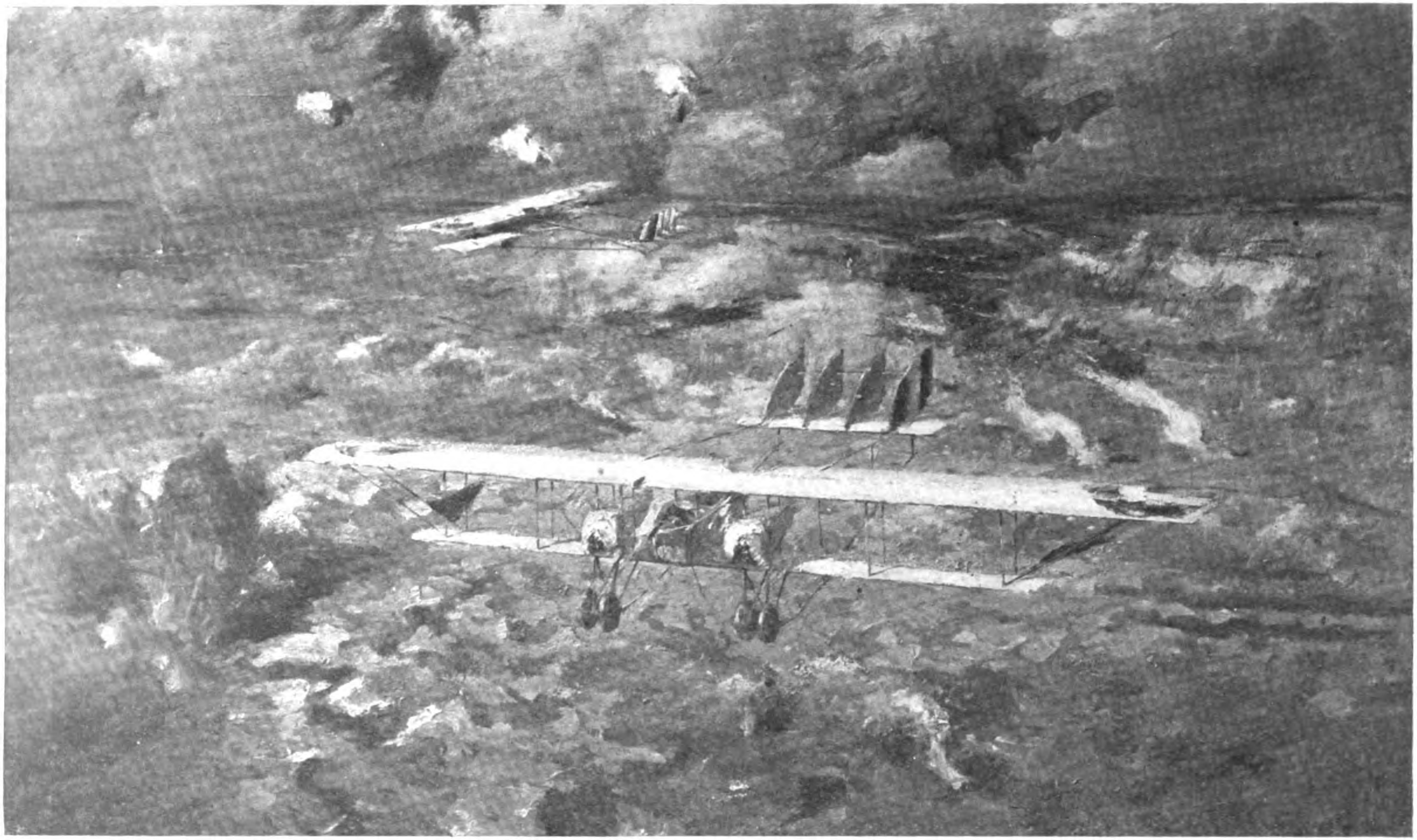


The Battle Field Over the Somme

The painting of which this is a photograph shows vividly how the soil has been turned up by shell fire. The flame and smoke indicated are made by bursting shells covering the entire field. The story shown in the painting is that of a Coudron, which, in order to see what is passing on the ground, flies low and between the bursting shells. Profiting by this aerial promenade along terrific lines of battle, the bombardier shoots soldiers in the trenches

VOLUME 5, No. 7 APRIL, 1918

THE WIRELESS AGE

WORLD WIDE WIRELESS

Salvador-Mexico Wireless Opens

WIRELESS communication has been established between Mexico City and San Salvador. The wireless plant at the Salvadorean capital was presented to that country by Mexico and installed by Mexican electricians.

British Ship Regulations More Stringent

THE Defense of the Realm Regulations which make compulsory the installation of the wireless telegraph on certain British ships of 3,000 tons and upward, has been amended by the reduction of the tonnage to 1,600.

Wireless News Agency Reorganizes

THE reorganization of the Agence Radio is announced from Paris. In the Spring of 1916 newspapers began printing news dispatches "By Agence Radio." Thus the world believed that a rival had been created to the long-established, semi-official Havas. The old agency had been crippled because most of its young employees resigned to engage in military service. So the new organization, employing only men free from military obligations, was able to make a good showing. Little was known about it for some time, beyond that it seemed to specialize in Greek news and was understood to be financed by a wealthy Greek, M. Basil Zaharoff, long resident in Paris.

The agency was founded in February, 1916, as a private company, with one stockholder, who had supplied a capital of exactly $305,000. This company is being liquidated and a new one formed, an ordinary limited liability company, to which various manufacturers and business men have promised to subscribe.

The Radio Agency did not spring into existence in 1916 without previous incubation. As a matter of fact, M. Turot, its director, had been at work for some years before the war on a plan to establish an opposition agency to Havas, to be called "The Potentia Agency," and had made many journeys abroad to look for representatives and connections. This preliminary work was utilized when Radio was started.

Mexicans Foil Plans for Secret German Plant

UPON a lonely spot near Alamo on the Lower California Coast, Germany plotted to erect a secret wireless plant through which was to be flashed to Berlin military information gathered by the Kaiser's spies in America and elsewhere.

Details of the plot, hatched in San Francisco in September, 1914, were drawn from the lips of Gustav N. Koeppel, San Diego shipping broker, by United States Attorney John W. Preston, recently in the German-Hindoo revolt trial in San Francisco.

Central figures in the plot, which failed, the witness said, only because of the alertness of the Mexican authorities, were named as Robert Capelle, agent of the North German-Lloyd Steamship Company, and E. H. von Schack, former German Vice-Consul in San Francisco.

In September, 1914, the witness said, he was summoned by telegraph to San Francisco by Capelle. Here he met Vice-Consul von Schack and the three discussed plans, he testified, to erect a wireless plant at Alamo, Lower California. His understanding was, Koeppel testified, that he was working for Capelle, whom the Government accuses of being the Kaiser's "paymaster" on the Pacific Coast,

Renewed objections by the defense and the admission of Preston that this plot was distinct from that charged to the defendants on trial prevented a detailed narrative of subsequent events. The witness asserted that a wireless plant and men were sent down to Alamo in a small boat, but there the Mexican Government interfered and several agents were arrested. To secure the release of these men, Preston asserts, was the reason for the "mystery trip" of Lieutenant Wilhelm von Brincken to Mexico, which figured in the trial of Bopp, von Schack, von Brincken and others and their conviction on charges of violating American neutrality.

In the transaction, the witness said, he handled large sums of money from Capelle, but could not give amounts. He received as compensation for his seryices in the wireless plot and in aiding the alleged conspirators in the shipment of arms and ammunition on the steamer Annie Larsen from San Diego two drafts for $1,000 each and his expenses.

German Raider Foiled by Operator

A DRAMATIC incident of the sea, in which a young wireless operator fooled the enemy, was related in the prize court in London recently, when the crown was asked to condemn the steamship Edna on the ground of unneutral service and enemy ownership.

The attorney-general, Sir Frederick E. Smith, described the kaleidoscopic history of a vessel which flew two flags. The plucky operator was "one Smith, an Englishman," who since has received a commission in the R. N. A. S.

Frederick Jebson, a German, said Sir Frederick, was a prominent man in San Francisco shipping circles. He chartered the vessel and was believed to have perished afterward in a German submarine. The vessel was built at Bergen in 1902 and in those days sailed the seas as the Jason. Jebson used the vessel for his Mexican business. He had been in the German navy and was in the naval reserve.

Jebson purchased the vessel, the ownership of which was vested in the Lloyd Mexican Societe Anonyme, in which he held the bulk of the shares.

Finally he managed to get back to Germany disguised as a Scandinavian seaman.

The Edna took on board wireless and gun-sight apparatus and tried to communicate to the German cruiser Leipzig the dates when British vessels left port—an attempt which was frustrated by the resourcefulness, ingenuity and courage of Smith.

In an affidavit read by the attorney-general, Guy Duncan Smith, the wireless operator, said that he was on board the vessel when the war broke out. He awoke one night at midnight and heard the steamship Aztec announce that war had been declared between Russia and Germany.

At this time the vessel had "Hamburg" painted on the stern. After the announcement that war had begun, "Hamburg" was removed from the vessel, "La Paz" was painted in and the Mexican flag was run up.

Before leaving San Francisco he had heard that the coal taken on board was intended for the Leipzig. Information was sent to the British consul, and the authorities at San Francisco demanded that the coal should not be delivered to the cruiser.

A German wireless operator was taken on board and Smith was told that if he refused to do his duty the German would take his place. The German operator, however, did not understand the Marconi system. Smith shortened the length of the waves, and though he appeared to be sending out calls for the Leipzig no vessel could pick up the message.

The German operator spent three nights and three days trying to call up the Leipzig. Smith returned later, and then occasionally called up the German cruiser, putting the wireless in order to allay suspicion, but the wireless was always out of gear when the German operator tried to use it. At La Paz, Smith forwarded a message to the admiral on the American cruiser California.

Some of the officers threatened to shoot Smith and throw him overboard if he did not send a code message to the German cruiser, and he then pretended to send it.

The only thing that Smith sent to the Leipzig was an inquiry as to where she was, which brought forth the reply that she was hanging around waiting for the Edna. Finally the Edna was commandeered by the Mexican Government, which put an officer on board, and Smith said that "after that things were more comfortable."

Florizel's S O S Means of Rescuing Forty-four

A WIRELESS appeal for help, adding that the steamship was breaking up, was all that was heard from the Florizel on February 24th, until rescue parties reached the scene.

Huddled into the wireless room of the wrecked steamship Florizel, the passengers and crew who had not been drowned or killed when the Red Cross line vessel was piled up on the ledge off Broad Cove, watched many of their number die before their eyes or saw them swept to death in the raging sea. They stood so closely that they could not sit or lie down.

Without water, food or adequate clothing to protect them from the bitter

weather, they faced death aboard the rapidly breaking up vessel, until the forty-four survivors were rescued by means of as gallant and daring seamanship as has ever been displayed, even by the men of Newfoundland, the best seamen in the world. They were there twenty-six hours. Some, injured by flying timbers, blocks and other wreckage, died as they stood. The stronger cheered and encouraged the weaker to hold out. Cecil G. Carter, wireless operator was among the survivors.

Another Sayville Disclosure

WHEN broad-gauged men enter into the field of wireless investigation, many interesting things are bound to follow. In John R. Rathom the United States has a contributor in the field of a unique order. Formerly a war correspondent in the Soudan and in Cuba, and member of expeditions to New Guinea and Alaska, this citizen of the world is becoming as well known to wireless men as those who have disclosed technical advances and unraveled engineering problems. The Wireless Age has chronicled Mr. Rathom's exposures of German intrigue before and readers have found them of absorbing interest because of their connection with the operations of the Sayville station, the spark of which, before the declaration of war, was almost as familiar to amateurs as the sound of their own voices.

In a recent address to the Traffic Club of Chicago Mr. Rathom added further interesting details of his work and that of his associates on the Providence Journal in ferreting out the sinister activities of the German Government's agents while this country was neutral. His early efforts in the wireless espionage he outlined as follows:

"On the day that war was declared with Germany by the various European nations, some good fortune or some good angel suggested to us that we listen in on Sayville and Tuckington. We began to listen in, and for a period of nearly five months with operators working in shifts of two men eight hours a day apiece, we accumulated fifty or sixty thousand sheets of wireless messages, without saying anything to anybody about what we were doing. We then presented a brief—we were not lawyers—but a common sense brief to the Government of the United States. One night at the White House, with the Secretary of the Navy and the President and several members of the Cabinet and members of the Neutrality Board, we made our disclosures, covering a period of four or five hours, and we proved exactly the character of organization that this Sayville station was. The Navy Department had been instructed by the Government, at the beginning of the war, to listen in on Sayville from the Brooklyn Navy Yard, but unfortunately that had not been done; and the only existing record that we knew anything about of what transpired during that first five months was our record.

"When I was able to show to the President that in one week little Anna, the daughter of a very prominent New York banker—a German-American so called—had died six times in eight days, and that on each occasion her body had been placed in a differently named room in a house, and she had died of a different disease, and was to be buried next day in a differently named circle—I asked him if he believed that little Anna did die six times in eight

days, and he said he did not. An then we proceeded to give to the Government an immense mass of names, positively proving that several hundred very prominent German-Americans in this country had been acting for four or five months as treasonable correspondents of the German Foreign Office.

"As a further result of our wireless revelations—and I may as well say that from that day to this, until the day that Sayville was closed up, we maintained our watch over that station—we were enabled to secure positions in a number of consulates throughout this country, and in the German embassy itself, for our own representatives."

Mr. Rathom declared that well known commercial houses of German extraction in the United States were outposts of the German Foreign Office and on this line remarked:

"The Siemens-Halske Company of Germany, as most of us know, is the great electrical company of Europe, and probably the greatest electrical corporation in the world. They have their agencies in every great city in the world, all through North and South America, the Philippines and everywhere else.

"One day we discovered through one of the consular general offices, the existence of a blueprint map of the Philippine Islands, accompanied by a letter from the Siemens-Halske Company to their own agents in the City of Manila, the letter making this statement: 'We send you herewith a blueprint map of the Philippine Islands with names and numbers of fifty-four locations for wireless installations marked. This map must be carefully guarded. It comes direct from the Foreign Office.'

"These people were instructed to bid so low on wireless construction, under our Government work, that nobody else could possibly get the bid, and after securing the bid to notify our Government or people that they could only undertake the work if their superior radio knowledge was consulted as to the location of the stations.

"This order was given to this concern, Siemens-Halske Company, and through them to their agents, that these stations must be located as marked on this map, so that when Germany comes into possession of the Philippines they will be exactly where they are wanted."

Search for Enemy Station Near New York

THE activities of German agents still here has been largely speculated upon in connection with the possibility that reports of troopships sailing from New York are sent by secret wireless stations in or near that city. Early in March the metropolis was thoroughly searched, the investigation being based on the fact that several weeks previous radio experts at Fort Totten discovered that there was a powerful wireless station in the city in communication with Europe. Partly decoded messages caused a suspicion that reports of departing steamships may have been sent to Germany or to commanders of submarines.

A secret detecting station was established on the roof of the Hotel Majestic. It was said the search for the undiscovered wireless is very difficult because probably no aerials are necessary for its successful operation. Any

steel construction in the roof of a building will act as a carrier for the radio waves. It is believed to be in the top of a skyscraper.

The delicate instruments necessary for the detection of the concealed wireless were installed in the valets' room of the hotel, under the roof. The receiving mechanism was attached to the huge electric sign on the roof. Day and night intelligence officers sat under the roof, with head phones fastened on, "listening in" to all the radio messages that vibrated through the air.

One by one their source was detected and accounted for. They came from all directions along the coast, and, when checked up, proved bona fide. Then a cipher message, evidently generated by as powerful a machine as is used by the Government, was suddenly intercepted.

It was received at night and was instantly identified as a hostile message.

Sensitive instruments able to measure distances convinced the intelligence officers that the dangerous wireless they were seeking was within a very few miles of the hotel. Some clue led them to the Trinity Building.

The tower's tenant was found to be Richard Pfund, a German-American, who is a radio expert and who showed credentials to prove he is in the service of the Navy Department. Prior to the European War he was general manager of the great Telefunken Company's wireless plant at Sayville. He was present when the officers arrived. He refused to allow them to enter the tower, which he said he used as an electrical laboratory and experimental station, until he obtained permission from the Navy Department.

When Pfund was questioned he satisfied the army men he was connected with the navy and engaged in Government work. He had checks and other credentials to prove it. Examination of the wireless convinced the Government agents it had not been used for some time.

On the same day, in upper New York, discovery by the State Constabulary of two suspicious wireless outfits, one completely set up, in the custody of W. I. Roemer, a German, in Hortonville, Orange County, created a sensation. The police are now on the trail of secret stations, one of which, they are informed, is in a New York suburb.

Roemer was employed on the large farm of A. K. Woodman, a wealthy resident wintering in Palm Beach, and was in charge when State policemen made the discovery. The troopers saw knobs and other apparatus on the roof of a gristmill on the Woodman place and, going inside, found the apparatus and another complete outfit which was not set up. The troopers intimated in their report that Woodman, who is away, probably knew nothing of the plant. According to the police, a powerful dynamo in the gristmill assured the wireless apparatus of power for a wide radius.

The police say that the vicinity is a hotbed of pro-Germanism. The law requires that any one having wireless outfits must have them sealed by the Government, but these were never sealed. The State police notified the naval intelligence officers, who confiscated the equipment.

Brazil to Have New Station

A RADIO STATION is to be established at Boa Vista do Rio Branco, in the State of Amazonas, Brazil. Consul-General A. L. M. Gottschalk reports that the sum of $50,000 (U. S. currency) has been appropriated for this purpose. The station will be under the control of the Brazilian Ministry of Transportation and Public Works.

Radio Science

Antenna Control for Radio Telephony

IT is quite probable that the vacuum tube has solved the problem of control of radio frequency currents in wireless telephony. But in the face of all the research work conducted along this line there has been devised a method of antenna control by Mr. Paul Hackett in which mechanical features predominate.

As shown in the accompanying drawing, figure 1, the inventor first generates continuous oscillations by means of the direct current arc, the oscillation circuit of which is inductively coupled to an antenna in the usual manner. Across the secondary inductance is shunted a series of special air condensers the capacity of which is altered at vocal frequencies by means of microphones and magnetic telephones as shown. In figure 1, wire 8 is connected in parallel to the flexible diaphragms 10 of one or more air gap condensers. The wire 9 is connected to the rigid diaphragms 11.

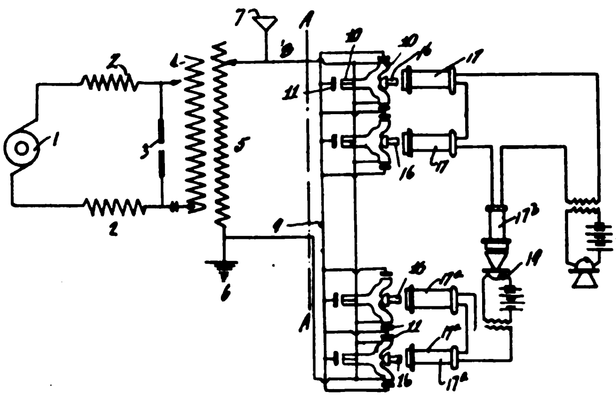


Figure 1—Method of antenna control in which mechanical features predominate

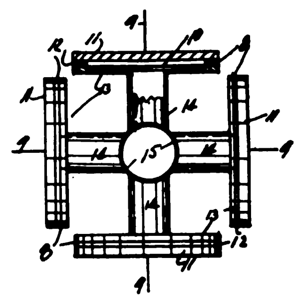


Figure 2—A detail of the condenser

A detail of the condenser is shown in figure 2, where pairs of the diaphragms are separated by an insulating ring 12. A complete unit of condensers consists of two or, preferably, four condensers which are connected by cover plates 13 having tubes 14 which terminate in a single tube 15 and mouthpiece 16. Each condenser unit is actuated by ordinary telephone receivers as shown at 17 and 17a.

These receivers may be connected either in series or in parallel with a high power transmitter such as 18.

Additional receivers may be inserted in the circuit between the transmitters 17 and 18, as, for example, the receiver 17b which actuates the transmitter 19.

When the transmitter 18 is spoken into an amplified action is obtained upon the diaphragms 10 which varies the capacity of the condensers shunted about the secondary winding 5. The amplitude of the radio frequency current is modulated

at a vocal frequency and the speech is reproduced in the receiving apparatus in the usual manner.

An Improved Target for X-Ray Tubes

A DIFFICULTY of considerable magnitude in the X-ray tubes heretofore employed has been the heating of the ray target or anode. With tubes operating by virtue of ionization of the residual gas and supplied with rectified alternating current, large power inputs could be used for a few moments because of the intermittent nature of the applied current, but under continued use disintegration of the anode results. Tubes employing the *pure electron discharge,* however, may be operated continuously on low powers without excessive heating. But when they are employed at high powers disintegration or tearing of the anode results. Experiments have shown that this disintegration is the result of the mechanical tearing caused by the rapid expansion and contraction due to the intermittent conveyance of heat from the ray-receiving face to the cooled section of the anode.

A tube has been designed by W. D. Coolidge, in which the anode is preserved intact by making its face of sufficient thickness to afford heat storage capacity great enough to transfer the variable heat input to the actively cooled parts of the metal at a rate nearly uniform. Coolidge's method of construction is particularly applicable to an anode comprising a face plate of highly refractory metal such as tungsten, and a backing of other metal such as copper.

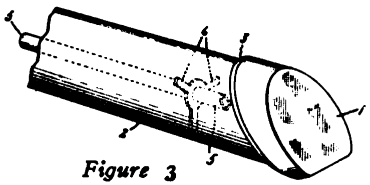


Figure 3

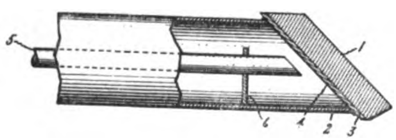


Figure 4

Figures 3, 4—*X-ray target in perspective and cross-section*

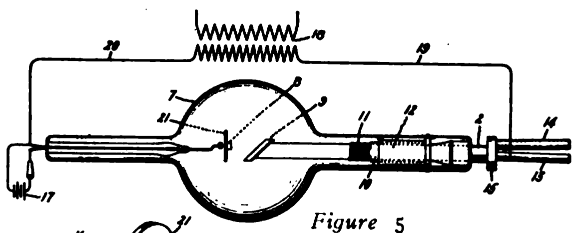


Figure 5

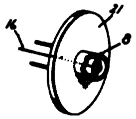


Figure 6

Figure 5—*X-ray tube with improved target*
Figure 6—*Detailed view of cathode*

Figure 3 illustrates an X-ray target in perspective; figure 4 a cross-sectional view, and figure 5 an X-ray tube with the improved target. Figure 6 is a detailed view of the cathode. The target shown in figures 3 and 4 comprises a ray-receiving plate 1 consisting of tungsten or other highly refractory metal, and a backing tube 2 the end wall 3, which is in intimate heat conveying-relation to plate 1. When the end wall 3 of the cooling device consists of copper, a weld may be secured by melting boronized copper in contact with the tungsten plate in a vacuum. The copper plate 3 may then be soldered or welded to the tube in any convenient way; for example, as indicated at 4. A tube 5 supported and centered by lugs 6 permits the introduction of a cooling fluid such as water.

The target, 1, should be relatively thick as compared with face plates heretofore employed in water cooled X-ray targets. A tube capable of operating with a current of about 0.1 amperes at about 50,000 volts and at a frequency of 60

cycles requires a tungsten plate about ¼ inch in thickness. The heat delivery will then be uniform enough to reduce the tearing or disintegrating effect of rapid expansion and contraction of the backing metal. Such tubes will have a very long life.

Figure 5 shows one form of X-ray tube in which the target has been operated continuously for days at a time without breakdown. It comprises the usual glass envelope 7, an electrode emitting cathode 8, and a water cooled anode 9. The tube 2 is mounted on an iron tube 10 bound by a wire 11. A glass tube 12 joined to the envelope serves to center and support the tube 2. The cooling fluid is supplied by tubes 13 and 14 through the junction box 15 to the anode. The cathode filament, figure 6, is heated by a battery 17 or other convenient low potential source. The main current is supplied by a transformer 18.

The tube is evacuated to a pressure so low that traces of positive ionization are substantially absent. When the tube is operated with alternating current any slight amount of gas evolved from the anode is electrically precipitated by a discharge emanating from the electrode 9 when acting as the cathode for a current wave negative with respect thereto, thereby vaporizing or sputtering copper. When a uni-directional current supply is used, the focusing ring 21, figure 6, is made of copper or other metal which is readily sputtered. Positive ionization of residual gas causes positive ion bombardment of the cathode and sputtering of the focusing ring resulting therefrom improves the vacuum.

Preparation of the Cathode for Pure Electron Discharge Apparatus

SOME of the characteristics of the pure electron discharge are absence of conductivity in the space between independent unheated electrodes, a variation of the current over a certain range with the 3/2 power of the voltage, the absence of blue glow in the space, the absence of gas fluorescence, and the lack of cathodic disintegration. It has been found that the electronic emission of platinum, carbon, tungsten, molybdenum, while differing to some degree is of the same order of magnitude, but Dr. Irving Langmuir has discovered that the electronic emissivity of pure thorium exceeds that of any of the elements mentioned.

The electrodes need not necessarily consist entirely of thorium. When, for example, a thorium compound such as the oxid has been added during the process of production to one of the highly refractory metals such as tungsten, and the metal subjected to a preliminary heat treatment in a high vacuum, the electron emission is enormously increased. The increase is not due to the presence of thorium oxid, but according to all indications is a property of metallic thorium on the surface of the cathode.

Apparatus for preparing a thoriated cathode is shown in figure 7, in which the anode consists of a film of refractory metal on the inside wall of the envelop produced by vaporizing a refractory metal of a high temperature. Figure 8 is a device operable as a rectifier having a thoriated cathode and plate-shaped anodes. Figure 9 illustrates a modification in which active thorium material may be transferred to the cathode from an independent thoriated conductor.

The device shown in figure 7, comprising an envelop 1 consisting of glass or quartz, provided with two filamentary conductors 2, 3, of highly refractory metal, such as tungsten, at least one of which, say filament 2, is thoriated. They are connected to leading-in wires 4, 5, sealed to a stem 6. The envelop is connected to a vacuum system by a tube 7, containing a trap 8 which may be surrounded by a freezing bath, such as liquid air, contained in a Dewar flask 9, or even an ice and salt mixture. It is the function of the freezing bath to prevent mercury, or other vapors, from the vacuum pumps from reaching the envelop. The usual methods of producing a high vacuum are employed for the preliminary evacuation of the envelop. This includes baking out the envelop to remove water

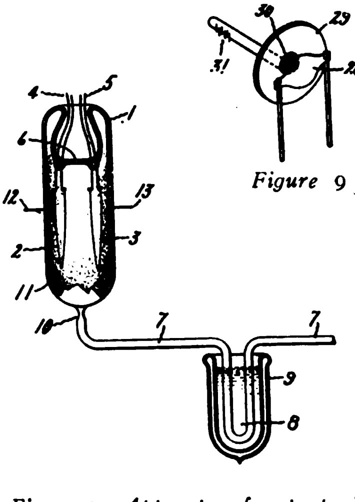


Figure 9

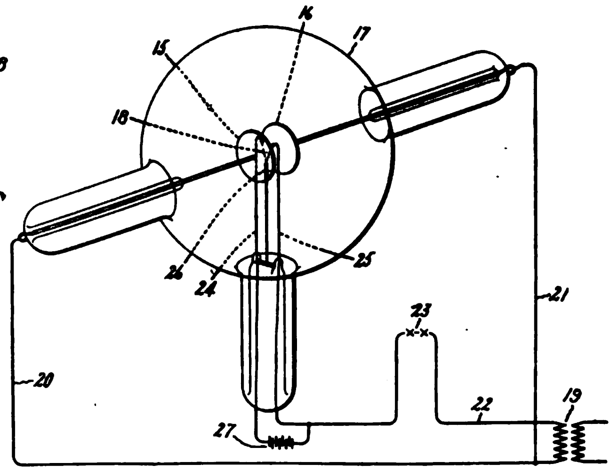


Figure 7—Apparatus for preparing a thoriated cathode

Figure 8—Device used as a rectifier; having a thoriated cathode and plate shaped anodes

Figure 9—Another form of rectifier, having active thorium material transferred to cathode from an independent conductor

vapor. The final stage is preferably carried out by a Gaede molecular pump to the highest possible vacuum obtainable by this means, namely, about .001 micron. While the apparatus is still on the pump the filaments 2, 3, are heated to a temperature of about 2,900° K. (absolute) for a short time and the envelop 1 is baked out in an oven at a temperature of about 360° to 450° K. The apparatus may then be sealed from the vacuum system at the contraction 10. It is then preferably immersed in liquid air and both filaments 2, 3, aged by heating for about ½ hour to a temperature of 2,400° to 2,500° K. One of the filaments, for example, filament 3, is then incandesced by a passage of current to a temperature of about 3,000° K. which causes rapid vaporization of the metal, thereby producing a gas-free conducting deposit or coating 11, which has been shown in the inner surface of the envelop. Conductors 12, 13 sealed into the envelop make contact with this coating and enable it to be used as an anode for an electrical discharge.

The cathode conductor 2 is prepared by introducing a thorium compound, such as the nitrate of thorium to the oxid of the refractory metal before reduction, or by adding either thorium nitrate or thoria to the metal powder after reduction, but before consolidation of the metal by sintering and mechanical working to the solid metal state has taken place. The proportion of thoria in the unsintered metal usually varies from about ½ to 10%, but in some cases may be even greater.

The thoriated cathode 2 is now heated to about 2,900° K. for about one minute. The treatment of the filament at a temperature of 2,900° has no marked effect on the subsequent electron emission of the cathode when at lower temperature, but appears to be desirable for purifying the surface of the cathode. The cathode is then incandesced from say 2,000° to 2,400° K. and by this temperature treatment some change is produced in the cathode which enormously increases its electron-emitting property. The greatest activity is obtained between about 2,200° to 2,300° K. and the treatment at this temperature is usually continued for about one minute, but even outside of this range a marked change is produced. Apparently a concentration of metallic thorium or of some other

oxidizable thorium material takes place on the surface of the filament. The filament 2 may now be used as a cathode at a temperature below the forming temperature.

With a filament thus prepared at a temperature of about 1,300° to 1,380° K. substantially the same electron emission per sq. cm. has been secured as with a pure tungsten filament at about 2,000° K., that is about three miliamperes per sq. cm. Preferably a thoriated cathode is operated around 1,700° to 1,800° K., at which temperature its life is indefinite.

One of the most striking proofs that the active surface film is not due to the effect of the thoria as in the Wehnelt cathode is furnished by the effect of a minute trace of oxygen on the behavior of the cathode. If in some manner a trace of oxygen is admitted, the electron emission immediately falls as low or even lower than the low value observed when a cathode of pure tungsten is slightly oxidized. In other words, the electron emission becomes very much lower than that of the unoxidized metal. When subsequent to oxidation a trace of hydrocarbon vapor is admitted, the electron emission suddenly rises as though reduction were taking place.

Another proof that the high electron emission is due to a skin of thorium is the fact that metallic thorium itself, particularly when free from surface oxidation, exhibits a very high electron emissivity for a given temperature as compared with tungsten. Difficulties are encountered with the use of metallic thorium as cathode material due to its relatively low melting point and its susceptibility to oxidation.

The apparatus shown in figure 8 does not differ essentially from the apparatus shown in figure 7, plate shaped anodes 15, 16, consisting of a highly refractory metal such as tungsten, being used instead of the film anode of vaporized metal used in the apparatus shown in figure 7. The envelop 17 is baked out and evacuated as already described in connection with figure 7. The ionizable gas should be removed from the anodes during the final stages of the exhaust, after the pressure has been reduced below about 1/10 of a micron of mercury by subjecting the anodes to an electron discharge from the cathode 18, whereby ionizable gas is evolved. This gas should be removed as fast as liberated and the discharge voltage progressively increased, care being taken not to materially exceed the voltage at which blue glow takes place, so as to avoid injury to the cathode. The final stage of the evacuation is produced by vaporizing a tungsten conductor in a side chamber (not shown in the drawing), thereby producing the very high vacuum necessary for the operation of the thoriated cathode. The anodes 15, 16, may be both connected to one terminal of a secondary of the transformer 19, by conductors 20, 21, the cathode being connected to the other terminal by conductor 22, including a load circuit 23.

It is not absolutely necessary that the thorium should be introduced into the body of the metal during the process of manufacture. As shown in figure 9 a cathode 28 located opposite an anode 29 is provided with a film of active thorium material vaporized from the coiled filamentary cathode 30 heated by a battery 31. The cathode 30 may consist either of a thoriated cathode prepared as already described, or of metallic thorium. The inclosing envelop has not been shown, but it is to be understood that these parts are to be operated in a high vacuum. When the coil 30 consists of thoriated wire it is first rendered active by heat treatment at a temperature of about 2,200° to 2,300° K., as already described, and is then heated to a temperature of about 2,900° K. to distil off active material, some of which is condensed on the cathode 28. When the coil 30 consists of metallic thorium, it should be heated to a temperature near its melting point to distil some of the thorium on to the surface of the cathode 28.

Professional Operators

Edward Hilson

Captured By The Germans

Experience of the Operator on the First American Ship Deliberately Sunk by a German Submarine—Enemy U-49 Activities in Submarine Campaign

By Edward Hilson

Chief Operator on S. S. Columbian

OUR ship offered a very tempting target for submarine attack. The Columbian was under charter to the French Canada S. S. Co., and carried 1,500 horses and 10,000 tons of steel and copper, bound for France. Then again the German submarine U-53 had just made its raid off Newport, sinking five vessels, and shipping was growing nervous. Anticipating trouble the ship was equipped with a powerful auxiliary wireless apparatus in addition to its ordinary set. While loading the horses at Boston, late in October, 1916, a rumor prevailed that the Columbian and her sister ship The Mexican, which was also loading horses for France, would be torpedoed. Several of the engineers quit the ship when they heard the report, and it was necessary to send a radio asking for new engineers and other men to take the places of those who had left. Soon after, one very dark night, we left Boston with our valuable cargo bound for St. Nazaire, France. Counting officers and crew there were 130 aboard the Columbian.

Half way across the Atlantic a fire was discovered late one night in the hay down among the horses, but luckily it was quickly extinguished. As the war-zone was approached all the life boats were swung outboard and fully equipped for any emergency, while the men were given frequent drills. A few miles out from port the ship was boarded by a French mine pilot who conducted us through the mine fields and then through the locks to the naval dock, where commenced the unloading of the horses. A squad of French soldiers did the unloading and a group of German prisoners waited on the dock to lead the horses away.

Many German prisoners of war were at work unloading ships, stacking lumber and loading railroad cars. We stayed at St. Nazaire three days and then started on the way to Genoa, Italy, with the rest of the cargo.

Two days later, in the morning, we were startled by the report of a cannon. I was on duty at the time. When the shot had splashed in the water on the port bow, the captain ordered the ship stopped and came down to the radio room and gave me the ship's position, Lat. 44.01 North, Long. 8.31 West. I was directed to hold it, however, until orders were given to send. From the port holes in my room I could make out the submarine cruising about at a distance of three miles. Twenty minutes later a second shot was fired. The captain promptly ordered me to send the S O S, which I proceeded to do.

With the engines stopped we rolled in a terrifying manner, the waves surging across our decks, smashing in horse stalls and deck fittings. My first S O S brought no answer, nor did the second attempt, but a third call brought a reply from the Spanish Government land station at Cape Finisterre. The German submarines often use the distress call to lure ships to their destruction, which explains why we received no answer to my calls. The S O S often warns them to keep out of danger. I told the Spanish station that a submarine was cruising about and firing at us, but did not mention it was German; they asked if there were any ships near by to help us in case we were torpedoed.

The submarine now flew signal flags, but we could not read them. The captain ordered me to stop sending. We got under way again and the captain directed me to notify the Spanish station that the submarine had missed us. We had begun to breathe more freely when an hour afterward the submarine was again sighted, cruising three miles off. Shortly after she fired on us. The undersea craft was flying signals, but we could not make them out. The Spanish station now asked me what was my nearest port, when the submarine for the first time used her wireless and commanded us, "Stop using your wireless, ask no questions or I will shoot." It was then too late to talk with Cape Finisterre, but we picked up her message telling us, if we could not send any words, to send a long dash and they would know what had happened and would send a ship to our assistance.

The German meanwhile bombarded us with such messages: "Follow me or I will shoot," "Where are you bound?" "What is your cargo?" and "Where bound from?" They ordered us to turn, and because we could not turn quickly enough in the rough sea they threatened: "Turn at once or I will shoot."

We had passed a steamer that morning which, we afterward learned, the submarine had captured. During the night the submarine moved up to within five hundred yards of us, while the steamer kept on the other side of her. Near midnight I heard an English warship call Cape Finisterre to get information, but she received no answer. Early in the morning when I resumed duty I heard the Spanish King's yacht, the Giralda, calling to give us assistance, but I could not answer. She was at Coruna and had been sent to us by the Spanish Government. Every time I answered the submarine I signed off with the ship's call letters and used full power, but the German operator did not notice it. It was an anxious time for all of us. Throughout the night and early morning the waves swept the decks and now and then there would be a crash as deck fittings and horse stalls were swept overboard. I changed my clothes and put what valuables I could carry in my pockets, ready for the worst.

The Spanish station kept calling me, fearing the worst had happened, but I could not answer. At daybreak the submarine ordered us to "Come nearer and send a boat over to the submarine," and a little later, "Send the captain with papers to us." Meanwhile, a boat containing the first officer and crew returned from the submarine with a German lieutenant and eight Germans. Before our captain could leave the ship, the Germans were aboard.

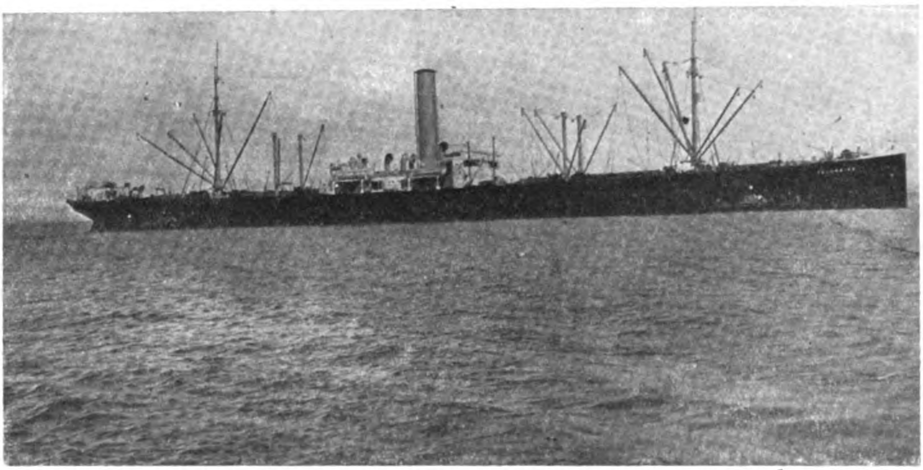
As soon as the Germans came on deck, they lowered the aerial, and the Hun operator made a bee-line for the radio room. He relieved me of the phone, stating he was now in charge. I noticed he carried two large bombs; these, he said, were for the purpose of blowing up the ship.

The Teuton immediately began to dismantle the wireless apparatus. Just then a German lieutenant came into the room with a drawn revolver; pointing it at me he said, "Don't you know you should not use your wireless when a submarine is around? We should have torpedoed you. I ought to shoot you."

I told him that I had obeyed the orders of the captain, and that when the submarine had told me to stop, I had stopped. This made him relent a trifle in manner, but he ordered me not to touch anything in the room and not to take my log book or any ship's papers out of the room under penalty of death.

After he had left, I asked the German operator to let me take the log book in which had been recorded every detail from the first shot until the Germans boarded us, but he refused. The book was lying on the table, and when the German's back was turned, I grabbed it, put it under my coat, and slipped out.

I found that the men were being lined up on the boat deck, all wearing life



When loaded our ship offered a very tempting target for submarine attack; we carried 1,500 horses and 10,000 tons of steel and copper, bound for France

belts. The captain was taken over to the submarine where, by the way, he was kept a prisoner until we landed in Spain. As the boat drew away, he shouted cheerily, "Goodbye, boys! I hope to see you soon. Obey orders." The boats were then lowered over the side. It took four husky sailors to keep the life boats from being smashed, as one by one the men climbed down a ladder and jumped into the tossing craft.

The Germans took one of the life boats and filled it with part of the wireless apparatus and provisions from the ice chamber. We were wet through, and the boat was half filled with water from the huge waves, so that it took us three-quarters of an hour to row to a steamer a mile away. When we reached the steamer, which was a Norwegian ship named the Balto, now a German prize, we climbed aboard and were lined up by the Germans. I saw that the men were being searched so I threw the log book into a little mess room back of me.

When my turn came to be searched, they took me to a room on the bridge where a German officer took my camera, razor, and all personal papers and valuables which I had saved, saying that I would get them back after the commander had seen them. I never saw the razor and camera again.

When all were off the Columbian, the two bombs were fired. All watched her for forty-five minutes, but we did not see any sign of her sinking. The submarine then maneuvered into position and fired a torpedo which struck her amidships, throwing a fountain of water as high as her smokestacks. She began to sink rapidly. Her after deck was soon awash. Her stern then dipped under and her bow rose straight up. She came up once and then the stern disappeared. The bow rose perpendicularly, the funnel level with the water, and then quickly disappeared, strewing the ocean with oil and wreckage.

Meanwhile some of our crew were compelled to load the provisions and supplies on the submarine and all fresh water was taken from the life boats. All the officers were ordered to stay in a little saloon and the crew to keep aft, some in the coal bunkers. That night we slept on the floor, or any place where we could lie down, and none of us had anything to eat. Next day we saw a steamer coming toward us and we were told to get ready to take to the boats which had been hoisted on deck. So once more we were obliged to enter the fragile craft.

I had thrown away my life belt as had most of the others. During a row of a mile before we reached this other steamer which the submarine had captured during the night, a big school of sharks followed our boats, and some of the sailors stood up and tried to hit them with their oars. She was a Swedish boat named the Varing. The Balto, which we had just left, had been in German hands for two days and a half before we sighted her. She had only a little cargo for a Portugese port, but it was clear that the Germans meant to sink her. After our crew and that of the Balto were aboard the newly captured Varing, several barrels of oil which were part of her cargo were thrown overboard and picked up by the submarine. A few minutes later the Balto was blown up by bombs. She caught fire and for several hours burned fiercely, sending up clouds of black smoke. Gradually she sank by the stern and burned until she disappeared.

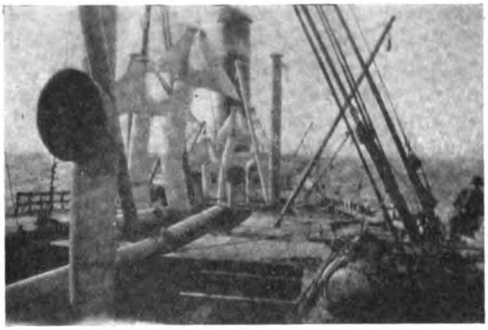
We hoisted all the small boats then on the deck of the Varing and the Germans painted out the names of the two sunken ships. The officers were put into a small saloon and the crew distributed below decks. We made a hungry, dirty crowd as we tried to sleep in these congested quarters on the floor. We got our first meal the next day. It consisted of a plate of pea soup, meat and potatoes. The day was bitterly cold and we lay on the deck around the fire and engine room in our overcoats trying to keep warm. The submarine proved to be the U-49. She was about two hundred feet long and carried, I was told, forty-eight men and two guns. Her crew had rigged up a temporary wireless outfit on the Varing, but used flags and lights to signal the submarine, which was never more than a mile away. The undersea craft also had a wireless aerial, and carried a long wireless mast fastened to the deck for long distance work. She had no marks or anything to identify her.

Late in the afternoon a steamer was sighted, the Norwegian Fordalen. The submarine started after her. She tried to escape, but the German soon overhauled her, hurrying her officers and crew into the boats, which were then rowed to the Varing. She was sunk by bombs in the same manner as the other ships.

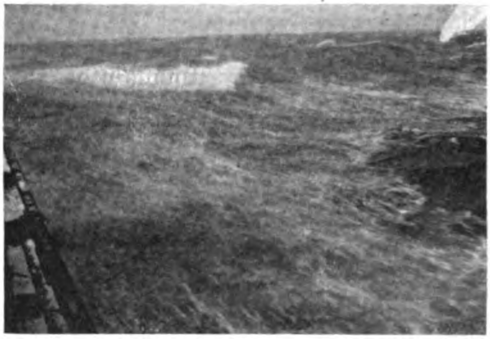
We now numbered over two hundred, including one hundred and thirteen of our own men, with all our life boats.

That night was clear with bright moonlight. During the same night the submarine sighted a steamer with all lights out. We prisoners were all ordered off the deck to our quarters. The first man seen on deck was to be shot. I watched the steamer from a port hole. She turned out to be a transport and must have noticed something suspicious about us, for she put on full steam and the submarine could not overtake her. Bombs had been placed all over the Varing, and in case of mutiny we would all have been blown up.

At two o'clock in the morning we were told that the Germans had decided to release us. The boats were lowered and we climbed into them; the captain



Deck view of the vessel printed from a role of film the Huns overlooked



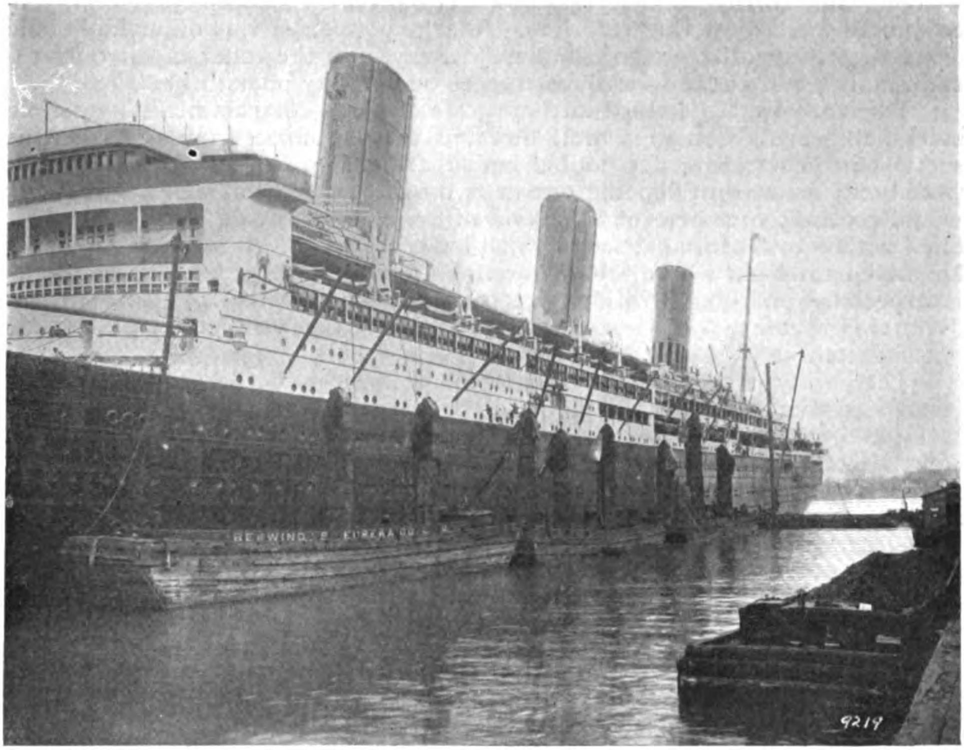
View of a rough sea taken on eventful trip of the Columbian

left before the German lieutenant had given him permission. The officer ordered him back, pointing a gun at him and threatening to shoot if he was not alongside in a minute. The demand was quickly complied with. Then without further incident we rowed toward the Spanish coast. Our boat was in charge of the captain of the Fordalen. Two men with us, having had their ribs crushed, were in the care of our doctor.

We rowed all morning, two to an oar, with the water to our knees. At noon we entered the little harbor of Camarinas. We found the submarine there and our boat was ordered to come alongside. Then we rowed a little longer and soon reached a fishing village, where I was certainly glad to land. The Germans were on the deck of their craft and they certainly were a dirty looking crowd. But I guess we were no better. We were weak, hungry, and smeared with grime. Water and wine were at once given to us and the crews were assigned to quarters, while the officers and myself, by the arrangement of the captain, were put up at the best hotel in the place. It seemed a palace to us. We could not wait until a meal was cooked, so the hotel people brought the food to us half done. Some of us slept two in a bed, and others on mattresses laid on the floor, but we all had something to eat.

We stayed there three days, when automobiles arrived to take us to Coruna, a day's journey. While there the American consul took our statements of the sinking. After eight days in Coruna we started on a journey of twenty-three hours to Madrid. Ten hours later a train took us to Cadiz, another day's trip. Here we stayed for over two weeks waiting for passenger accommodations back to the States.

By this time we were not looking any too slick, most of us having only what we stood up in. The consul had to give us heavy underwear on account of the cold weather. When we went to Algeciras, opposite Gibraltar, a long night's travel, it was without sleeping accommodations; the Spanish trains have no Pullmans. Here we had another enforced stay of over two weeks, making several trips to Gibraltar to secure passage, but without success. At last we moved on again, this time on a little Spanish steamer, the Llovera to Tangier, Morocco, half a day from Gibraltar, and thence to Cadiz. Here we waited more than a week, but finally left on a Spanish steamer, the Alicante, especially chartered to carry us and the crew of another American ship, which had been sunk by a submarine. We were scheduled to land in New York on Christmas Day, but owing to a rough passage of twenty days, we were disappointed. We did get in on New Year's Day, however, which wasn't so bad, all things considered. Beginning a new twelve month with feet firmly planted on the soil of Liberty is a very secure feeling, as may well be imagined after an experience such as mine. Try it once, and I think you'll agree.



Coaling the Vaterland in the days before she took on her camouflage paint and a cargo of American soldiers

Our New Troop Ship

Some Aspects of the S. S. Vaterland of Peace Days, Now a Soldier-Carrier for Uncle Sam

IN the world's largest steamship, the Vaterland, which is now under the American flag, may be found an excellent model for the construction of our merchant marine in the future. The newest ideas in construction evolved by the most expert of Germany's ship builders are embodied in this giant craft. No time or expense was spared in designing and constructing this largest and most luxurious of ships. By the fortunes of war the great liner, which was the pride of Germany, has come into America's possession, so that every detail of her construction and equipment may be studied and imitated with ease. It has already been announced that she has carried American troops abroad and it would be interesting to know the reflections in friendly and enemy minds during the voyage.

The Vaterland is not only the largest ship ever constructed, but in many respects the safest vessel afloat. She combines enormous carrying capacity with great speed and economy of space. In the event of her being attacked by submarines it is expected that her safety devices would render her practically immune. It is amazing to find that German genius in shipbuilding

may thus be employed by America to combat Germany's most effective weapon, the submarine. The Vaterland is built with a complete double skin extending well below the waterline. A large portion of this outer hull could be damaged, even be blown completely away, and the inner hull would remain intact, so that the ship could proceed on her way undisturbed.

The Vaterland is divided into upwards of forty compartments by strong steel bulkheads. Should a well directed torpedo fired from a submarine succeed in penetrating her double hull, tearing a great hole in her side, it would only succeed in flooding one or two of these compartments. The ship would continue to float even if several of her compartments were completely filled with water. In most ships which have been sunk by collision, the blow has fallen amidship where the engine room has been flooded. The Vaterland is especially provided with longitudinal bulkheads extending through her great engine room, so that even a terrific blow at this vulnerable point would not sink her.

The safety of the great vessel again is largely due to the marvelously efficient system by which the doors of the steel bulkheads are controlled by a single hand from the bridge. A great system of electric communication, comparable to the nerves of the human body enables the captain to control the furthermost corner of the ship. Should an accident, a submarine attack for instance, occur, the fact would be communicated instantly to the bridge. A single touch of a lever would cause the steel doors of the great bulkheads to clang shut without an instant's loss of time, thus localizing the trouble. A diagram of the ship's compartments has been placed on the bridge in which the position of every door is indicated by a small electric light. If any one

The Teutonic point of view in equipping the wireless cabin of Germany's greatest ship seems to have been favorable to establishing a laboratory, examination of the illustration disclosing a half dozen types of apparatus, probably replaced now with more businesslike equipment made in the U. S. A.

of these doors for any reason fails to close the light burns a warning red, and assistance may be instantly rushed to the danger point.

The preparation made to prevent fire or combat such danger should it arise is probably unequalled on any other ship afloat. The staircases and passageways have been especially treated with fire-proof material, rendering it practically impossible for fire to spread, exactly as in the case of our modern fireproof buildings. The crew of the Vaterland has included, trained fire fighters completely equipped with chemical engines, smoke helmets and other up-to-date fire fighting apparatus. The permanent equipment of the ship also includes automatic fire extinguishing apparatus, so distributed that in the event of the temperature rising above a certain point the deck would be automatically flooded with water. Still another precaution has been provided in the electric thermometer, which connects the remotest parts of the great ship with the bridge. Should fire break out, it would be quickly detected by the rise in temperature, and an alarm bell would ring on the bridge, indicating the scene of the trouble.

The staircases and passageways throughout the great vessel are very wide and commodious, and several batteries of electric elevators have been placed in different parts of the ship, so that one may rise or descend through half a dozen decks in a few seconds. All this equipment would prove invaluable when the ship was loaded to capacity with troops. In the event of a fatal accident thousands of soldiers could be quickly assembled at any point on any of the decks without loss of time. The complete system of telephone connections would also prove of invaluable assistance in maintaining instant communication between the bridge and every part of the ship. A telephone central station makes it possible to get a connection as quickly as on land.

The great deck and cabin space of the Vaterland would seem to have been designed especially for use in transporting great bodies of troops. A regiment of soldiers may drill on her decks, or in bad weather indoors in her great salon. The length of her decks makes it possible for the soldiers to keep in perfect physical condition throughout the sea voyage. There are, besides, two completely equipped gymnasiums with mechanical exercising devices to prevent the men from becoming "stale" during the voyage.

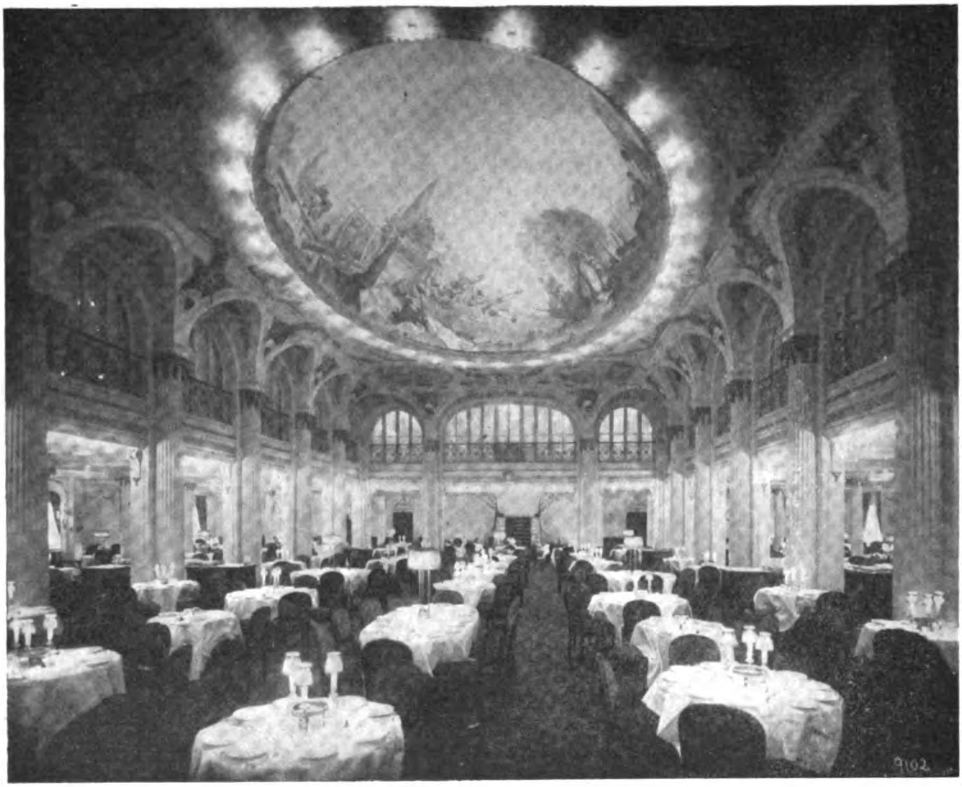
In normal peace times the Vaterland carries 5,000 passengers and a crew of over 1,000. She could readily carry 10,000 troops without undue crowding. The feeding of this army would offer no difficulties since the ship is equipped with three great kitchens. The newest mechanical devices for labor saving have been provided, including electric potato peelers, bread mixers, and similar devices. Troops can be comfortably, even luxuriously, served in three great dining rooms, the largest of which seats upwards of 1,000 persons.

It would seem that the present danger of attack from submarines had been anticipated in the construction of the Vaterland, so complete is her equipment for warding off such attacks. She has a highly sensitive microphone attachment which enables her to detect the approach of submarines for a considerable distance. This submarine device was employed in peace times to pick up submarine signals at the entrances of harbors. The great ship may be steered with this assistance into a harbor in a dense fog. The microphone attachment is placed well below the water line and is connected with a telephone device on the bridge.

On the broad decks will be found gun mounts placed with intelligent care at the most advantageous points to repel possible attacks. It is a simple matter to mount comparatively powerful guns on her decks, thus converting her into an effective cruiser. In constructing the ship all this has been anticipated and the decks strengthened to carry such guns without fear of weakening her frame. The Vaterland besides carried powerful wireless equipment. She had two complete sets, one for short distance work over a radius of a few hundred miles, and a second powerful set capable of sending messages across the Atlantic.

It was one of the boasts of the Vaterland officers that she carried lifeboats and rafts capable of caring for every soul on board, even when loaded to her extreme capacity. Her broad decks can readily carry sufficient lifeboats to provide for all the troops she may carry. These boats are provided with special apparatus for launching, operating electrically so that they may be lowered to the water in a few seconds. In peace times the Vaterland also carried powerful steam launches which could take these lifeboats in tow. The launches in turn were equipped with wireless apparatus, so that even in the event of a wreck when the ship must be abandoned they could summon assistance across the water wastes.

The overcrowded troop ship has been one of the discomforts of war. Troops transported by the Vaterland or any ship with her equipment should



Aside from safety factors, America's new troopship has a decided claim for the beauty prize in transports, as instanced in the dining room shown here

escape every hardship. They can not only be comfortably housed and fed, but have every want anticipated. In the great Roman bath of the Vaterland the soldiers can enjoy the pleasure and healthful stimulus of salt water bathing throughout the voyage. By utilizing the plunge throughout the twenty-four hours several thousand soldiers could thus be accommodated every day. The ship has besides upwards of 600 private bath rooms. The equipment also includes a completely equipped hospital with an operating room and stores of medicines.

On the whole the Hun appears to have made a valuable contribution toward the solution of the problem represented in the cry for America to get "ships, ships, and more ships."

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XII

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE—This is the twelfth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

GENERAL CONSIDERATIONS

(1) Elevated wires or conductors which are set into oscillation to radiate electromagnetic waves are termed **aerials or antenna.**

(2) The function of the antenna wires is two-fold:

(a) To radiate electric waves;
(b) to absorb energy from passing waves.

In other words, the same aerial is used for transmitting and receiving.

(3) **A plain aerial** without localized inductance or capacity at the base, oscillates by virtue of its **distributed inductance** and **capacity.** Hence, if a transient electric charge is given to the aerial such as by excitation from a series spark gap connected to a high voltage transformer, the antenna wires will **oscillate** energetically **at a radio frequency** determined by its electrical dimensions.

(4) The **length of the wave** radiated by an aerial can be determined from knowledge of its inductance and capacity, i.e., $\lambda=38\sqrt{L,C}$ where L is the distributed inductance in centimeters, and C, the distributed capacity in microfarad. Hence, as explained in a previous chapter, if the inductance is 100,000 centimeters (100 microhenries) and the capacity .001 microfarad, the wave length $= 38\sqrt{100{,}000 \times .001} = 38\sqrt{100} = 380$ meters.

(5) An aerial whose fundamental wave length is 380 meters requires the insertion of a localized inductance at the base to radiate at 600 meters. To radiate a wave of 300 meters a short wave condenser, usually of .0005 microfarad capacity, is connected in series.

(6) Aerials may take various shapes or forms. Four types are generally recognized in commercial practice:

(a) The vertical or fan aerial;
(b) the umbrella aerial;
(c) the inverted "L" flat top aerial;
(d) the "T" flat top aerial.

Either the "T" or "L" shaped aerials are employed for ship use.

The vertical and umbrella aerials are used at a few high power stations, but the inverted "L" flat top is preferred by the Marconi Company both for ship to shore and long distance communication.

(7) Generally, the type of aerial adopted is the one most convenient to the space available although financial considerations may be the governing factor.

(8) Flat top aerials are used at the majority of stations for the reason that they prove just as effective as vertical aerials, with a smaller initial expense of erection.

(9) Some fundamental points to be considered in the design of an aerial follow:

(a) The conductors must possess great tensile strength and good conductivity;
(b) they should be spaced from two to three feet apart;
(c) the wires must be thoroughly insulated at all points of support.

AERIAL INSULATORS

(1) Especial attention must be given to the insulation at the free end of a wireless telegraph aerial for, generally, the voltage there is greater than in any other part of the system.

(2) Aerial insulators must possess not only high specific resistance, but they must be of sufficient length to exceed the sparking distance of the voltage to which the aerial is charged.

Glazed porcelain possesses good insulating qualities, but the danger of breakage is considerable; the same statement applies to **glass. Hard rubber rods** have been used considerably for insulating the wires individually. **Composition insulators** such as **moulded electrose,** and others, are extensively employed.

Special insulators are employed to pass the lead-in wires through the deck, particularly if they extend through a steel deck.

DIRECTIONAL AERIALS

(1) It has been found that if the length of the flat top portion of an inverted "L" aerial exceeds the vertical portion, maximum radiation will take place in the **direction opposite to the free end.** A triangular looped type of aerial also will radiate with greatest intensity in the direction of its own plane. The directional properties of the flat top aerial were first noted by Marconi.

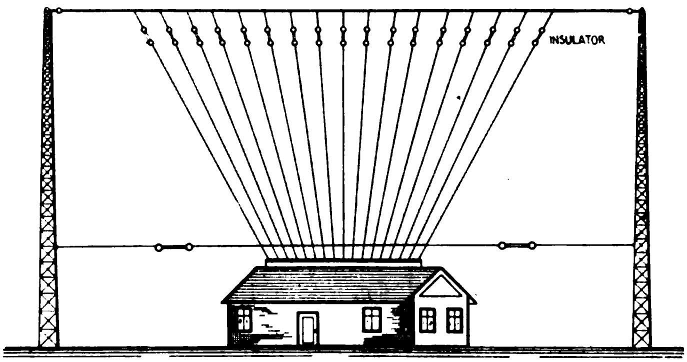


Figure 109

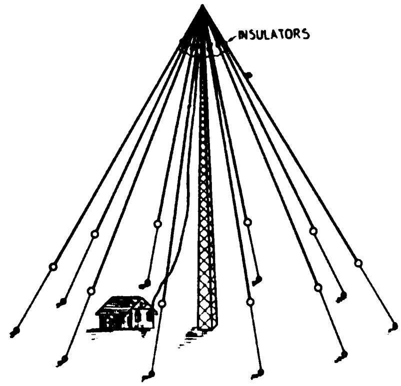


Figure 110

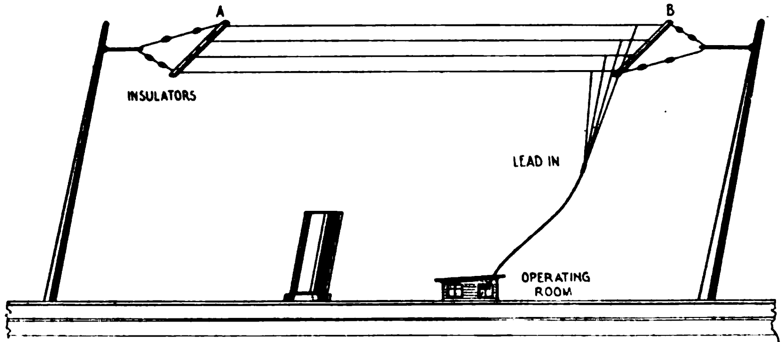


Figure 111

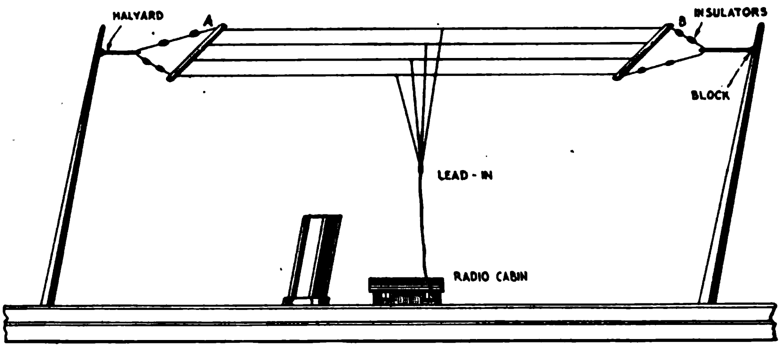


Figure 112

OBJECT OF THE DRAWINGS

(1) Figure 109. To show the construction of the vertical or fan aerial.
(2) Figure 110. To show the construction of the umbrella aerial.
(3) Figure 111. To show the construction of the inverted "L" flat top aerial.
(4) Figure 112. To show the construction of the "T" flat top aerial.

PRINCIPLE

The electric waves of wireless telegraphy are set into motion by causing an elevated conductor to oscillate at a radio frequency. The characteristic of the radiated wave is governed to a certain extent by the disposition and design of the aerial.

DESCRIPTION OF THE DRAWINGS

The **vertical aerial** in figure 109 consists of a fan or harp of **copper** or **silicon bronze**

wires supported vertically by a **wooden mast, steel tower,** or any convenient structure of sufficient height. The wires may or may not be joined at the top. All wires converge at the lower end where they enter the station house through a specially designed high voltage insulator.

The **umbrella aerial** shown in figure 110 receives its name from its general shape and similarity to an umbrella. A number of wires spread radially in several directions from a common center at the top of the mast. The lead-in wires are attached to the top wires of the ribs. The ribs of the umbrella are about two-thirds the height of the mast, but the guying out wires must be from 6 to 7 times the length of the downward wires.

The **inverted "L" flat top aerial** shown in figure 111 is employed almost universally for ship service. It consists of a number of parallel wires stretched between the wooden spreaders A, B. This is known as the **flat top portion** of the aerial. The vertical wires are attached to one end of the flat top from which they extend to the apparatus in the wireless cabin. These wires are known as the **lead-ins.**

The construction of the flat top portion of the aerial shown in figure 112 is the same as the type shown in figure 111 but the lead-in wires are attached to the center. This type is known as the **"T"** aerial.

SPECIAL REMARKS

(1) The umbrella aerial has been found of some value for portable military stations because the aerial wires can be used as guy supports for the mast, but beyond this, this type has little to recommend itself.

(2) The flat top aerials for ship's use generally consist of four wires spaced 2½ to 3 feet apart. 2, 6, or 8 wires are employed in special cases.

(3) To change an inverted "L" aerial of given dimensions to one of the "T" type reduces the fundamental wave length approximately one third. Hence, if the fundamental wave length of an "L" aerial is too great for radiation at 600 meters, the lead-ins may be attached to the center of the flat top. This is the recognized practice of the Marconi Company today.

(4) A more favorable decrement is secured with the "T" aerial as compared to an "L" aerial of the same dimensions because larger amounts of inductance may be inserted at the base (of the aerial) for a given wave length. The radiated wave then possesses qualities affording greater selectivity, that is, freedom from interference at the receiving station.

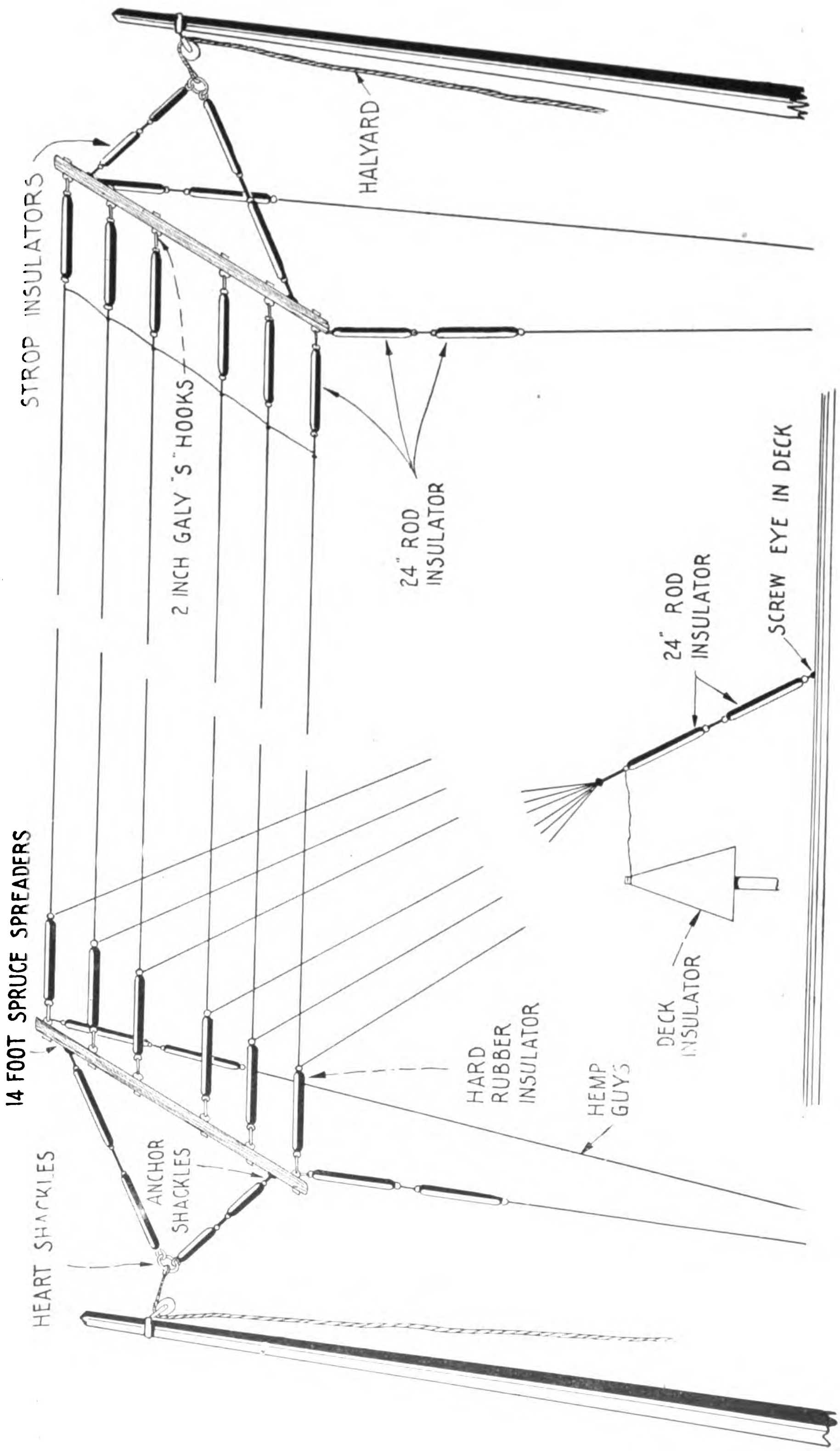

HALYARD
STROP INSULATORS
2 INCH GALV 'S' HOOKS
24" ROD INSULATOR
SCREW EYE IN DECK
24" ROD INSULATOR
14 FOOT SPRUCE SPREADERS
HARD RUBBER INSULATOR
HEMP GUYS
DECK INSULATOR
ANCHOR SHACKLES
HEART SHACKLES

Figure 113

OBJECT OF THE DRAWING

To show the practice of the American Marconi Company in respect to construction of ships' aerials.

DESCRIPTION OF THE DRAWING

The antenna consists of six wires equally spaced on **spruce spreaders** from 14 to 18 feet in length. Each wire consists of 7 strands of No. 18 **silicon bronze** wire. Each wire is insulated from the spreaders by 24″ **hard rubber or composition insulators.**

The wooden spreader is insulated from the halyards by **strop** insulators made up of ⅝″ Russian **boat rope** partially covered by rubber tubes. The space between the tube and the rope is filled with **melted sulphur** which, when it cools off, hardens and keeps out moisture. The strop insulators are attached to the spreaders and terminate in a heart shaped shackle to which galvanized iron **halyard** wires are attached for raising and lowering the aerial.

To prevent the spreaders from swaying, **side stays** are attached to the ends and fastened to the mast from 20 to 40 feet below the flat top. The stays are broken up by 24″ hard rubber insulators to prevent leakage of the high voltage currents.

The **lead-in wires** are attached to a connecting lug mounted on a deck insulator. The strain is taken off this insulator by two 24″ rod insulators attached to a screw eye in the deck as shown in the drawing.

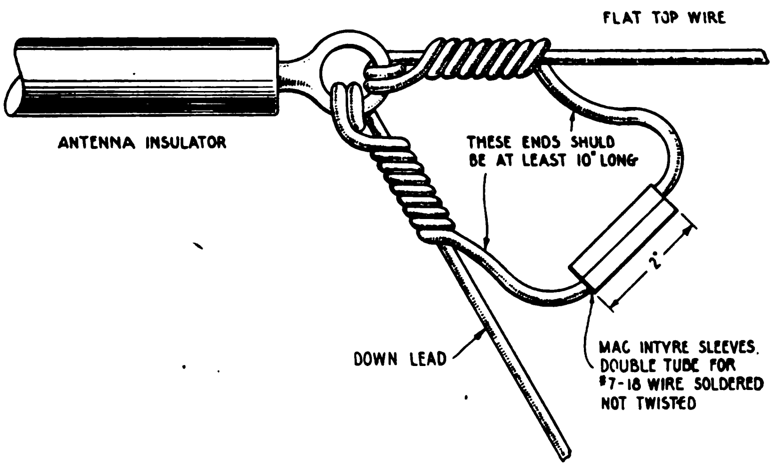


Figure 114

Figure 114—Showing how electric connection is made between the flat top wires and the ***lead-in wires*** *according to the practice of the American Marconi Company. To solder silicon bronze* ***wire anneals it and*** *reduces its tensile strength. Hence, antenna joints subjected to considerable strain should not be soldered. In the above sketch, the mechanical strain is taken care of by twisting the wires as shown,* ***but a thorough*** *electric connection is effected by a MacIntyre sleeve connector in which the ends of the* ***flat top wires and*** *the lead-ins are soldered.*

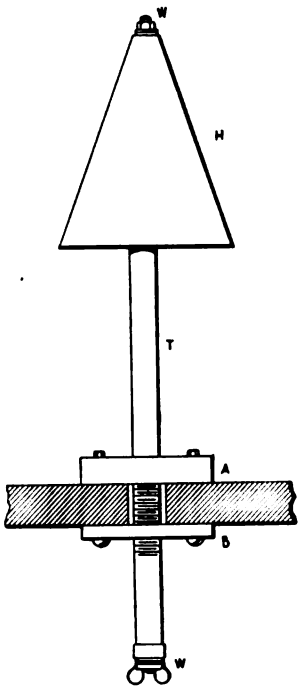


Figure 115

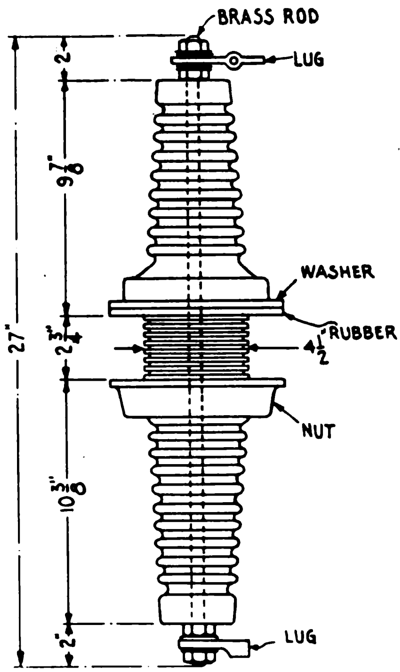


Figure 116

OBJECT OF THE DRAWINGS

(1) Figure 115. To show the general construction of the Bradfield type of deck insulator.

(2) Figure 116. To show the general construction of a special Electrose moulded insulator used by the American Marconi Company.

DESCRIPTION OF THE DRAWINGS

The deck insulator of figure 115 consists of a long **hard rubber** tube "T" about 2″ in diameter which has a brass rod extending through it terminating at each end in a wire connecting lug W. The tube is threaded at the center to take the **wooden blocks** A, B, one of which is placed above the deck and the other underneath. After these blocks are drawn up tightly, they are held in place by wooden screws or lag bolts. To insure a water-tight joint a piece of canvas covered with **white lead** is placed under-

neath the blocks. A metal hood H fastened to the exposed end of the tube protects it from moisture.

The deck insulator shown in figure 116 is made of Electrose and has a heavy brass rod moulded securely into it which terminates at either end in a connecting lug. The outside of the insulator is threaded and after it is inserted in a hole cut in the deck a water-tight joint is made by taking up the collar R under which are placed rubber gaskets.

SPECIAL REMARKS

(1) Other types of deck insulators have been employed from time to time but the two just described are indicative of modern practice.

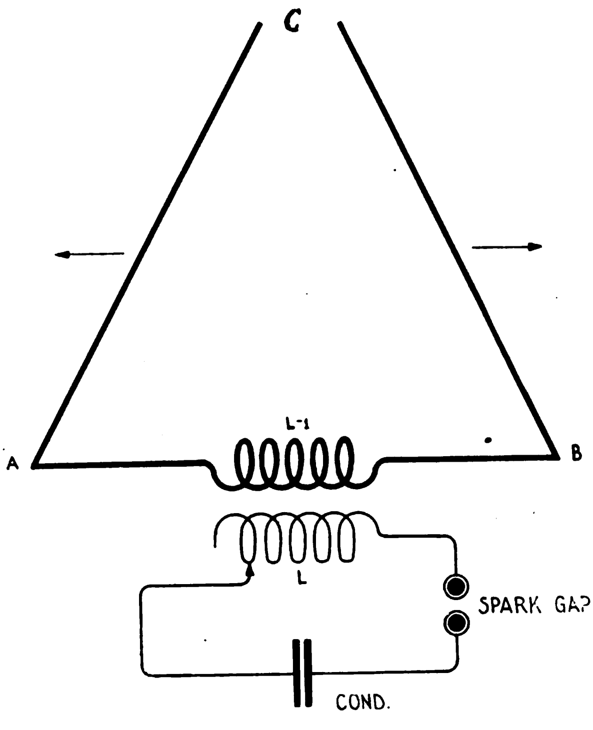


Figure 117

Figure 117—Showing the Bellini Tosi directional antennae. An aerial of triangular form A, B, C, is supported at the apex by a vertical mast (not shown). The two sides of the triangle A, C and B, C make an angle of 30 degrees with the vertical, and the third side is horizontal to the earth. The secondary winding of an oscillation transformer L-1 is inserted at the center. The circuit of the primary winding L includes the usual spark gap and condenser. When this circuit is set into oscillation, the aerial will radiate with the greatest intensity in the direction of its own plane, the radiation in a direction perpendicular to the triangle being zero. In any direction making an angle θ with the plane of the triangle the intensity of the radiation varies as the co-sine of the angle θ. The triangular aerial may be used for receiving purposes as well and if it be arranged so that it can be turned on its axis, the greatest strength of signal will be obtained when the plane of the antenna points in the direction of the wave front. In modified form these aerials are employed in connection with the Marconi direction finder.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

ELEVENTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Instruction in Garrison Visual Stations

THE alphabet and conventional signals with the flag should be thoroughly mastered by means of wand drill, instruction in which is to be given regularly at such time as prescribed by the company commander.

Signal parties should consist of four men, equipped with the necessary visual signal equipment for the operation of one station. The instructor selects the point where the station is to be established and gives the location of the station or stations with which communication is to be conducted.

At the command *open station*, the signal equipment is made ready for use.

One man is designated to record incoming messages and to call off the words of the message being sent.

A second man manipulates the sending equipment and reads and calls off incoming messages for the recorder.

A third man watches the distant station for breaks.

A fourth man is messenger.

The signal party is made familiar with the various duties by frequently changing about the four men to execute each other's tasks.

Outside or field work is conducted by sections, which may be divided into convenient squads of four, chiefs of sections and their assistants being the instructors. These units lend themselves readily to the use of the flag, heliograph, and lantern, as well as for convenience in camping.

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

Telegraphy

Ability to telegraph by means of the American Morse code is a most important qualification for members of the Signal Corps. Only those who have adaptability for operating and are sufficiently educated should be given this instruction.

The instruction should be conducted in classes, under the direction of the company commander, by competent noncommissioned officers, and, when practicable under the personal supervision of a commissioned officer. The buzzer is used for this instruction and the men classified according to ability and progress. Instruction indoors is to be continued until the operator is sufficiently advanced to work to advantage on field lines, that is, when he has acquired ability to send and receive about 15 words per minute under service conditions.

Instruments should be provided in company headquarters so that they are accessible to the members at all times, encouraging the ambitious to rapid progress. Opportunity should also be given to use typewriters when members have progressed sufficiently.

The standard instruction of the United States Army for telegraphy serves as an excellent guide and is given here for the information of all instructors.

The Morse code as used in the Signal Corps consists of seven elements: (1) the dot; (2) the dash; (3) the long dash; (4) the ordinary space; (5) the letter space; (6) the word space; and (7) the sentence space. It is important to remember that the value of the space in the code is as great as that of the dots and dashes. The complete code is shown in the accompanying plates.

The arbitrary unit of time in this code, which, when written down becomes a unit of length, is technically termed the dot. An appreciable time is required for the production of signals by electricity, in the magnetization of the electromagnet, and in the movement of clockwork. The formation of a dot, therefore, necessarily involves time. Assuming, therefore, that—

(1) the dot is the unit of time.
(2) The dash is equal to two dots.
(3) The long dash is equal to four dots.
(4) The ordinary space between the elements of a letter is equal to one dot.
(5) The letter space is equal to two dots.
(6) The word space is equal to three dots.
(7) The sentence space is equal to six dots.

The recruit will first thoroughly commit to memory the groups of signs representing the letters of the alphabet, the numerals, and the principal punctuation points, viz., the period, the comma, and the point of interrogation. The remaining characters can be learned afterwards, as they will be little needed by the beginner.

The most approved manner of grasping the key, and one which has been employed by some of the most successful, experienced, and rapid operators, is shown in the illustration. Curve the forefinger, but do not hold it rigid.

Let the thumb press slightly in an upward direction against the knob. Keep the wrist well above the table. No better general direction can be given than that the key will be grasped, held, and controlled with the same flexible but perfectly controlled muscular action of the fingers, wrist, and forearm with which the skilled penman holds his pen. Carefully avoid tapping upon the knob of the key; the raising spring should assist the upward motion of the key, but should never be permitted to control it.

Correct manner of grasping key in telegraphing

By constant drill, as hereinafter directed, the habit of making dots with regularity, uniformity and precision must first be acquired; then dashes, and lastly, in order, group of dots and dashes, letters and words. In commencing, the habit should at once be acquired of making dots like short, firm dashes. The recruit should learn to form the conventional characters accurately and perfectly; speed will come in good time, but only as a result of constant and persistent drill.

ELEMENTARY PRINCIPLES

As a basis for practice, the code may be regarded as comprising six elementary principles, viz.:

First principle—Associated dots.

I	S	H	P	6
..	...	....	.....	......

Second principle—Associated dashes.

M	5	¶
--	---	----

Third principle—Isolated dots.

E

.

Fourth principle—Isolated dashes.

L or cipher	T
—	-

Fifth principle—Dot followed by dash.

A

. -

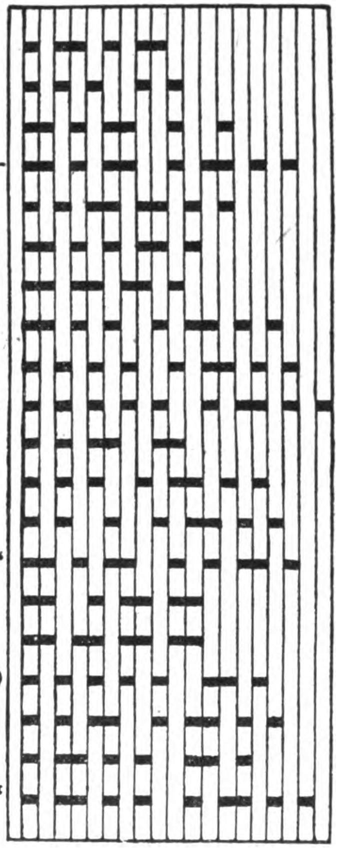
Sixth principle—Dash followed by dot.

N

- .

The learner's first practice is upon these elementary principles.

Comma,	,
Semicolon,	;
Colon,	:
Colon Dash,	:—
Period,	.
Interrogation,	?
Exclamation,	!
Dash,	—
Hyphen,	-
Pounds,[2]	£
Shillings,[2]	/
Dollars,[2]	$
Capitalized Letter,[2]	
Colon-Quotation,	: "
Decimal Point,	.
Paragraph,	¶
Parenthesis,[3]	( )
Underline,[3]	
Quotation,[3]	"
Quotation within Quotation,[3]	" '



(3) The *long dash* is equal to 4 dots;
(4) The *ordinary space* between the elements of a letter is equal to 1 dot;
(5). The *letter-space* is equal to 2 dots;
(6) The *word-space* is equal to 3 dots;
(7) The *sentence-space* is equal to 6 dots.

[2] To be used before the characters to which it refers.
[3] To be used before and after the words to which it refers.

Punctuation and miscellany

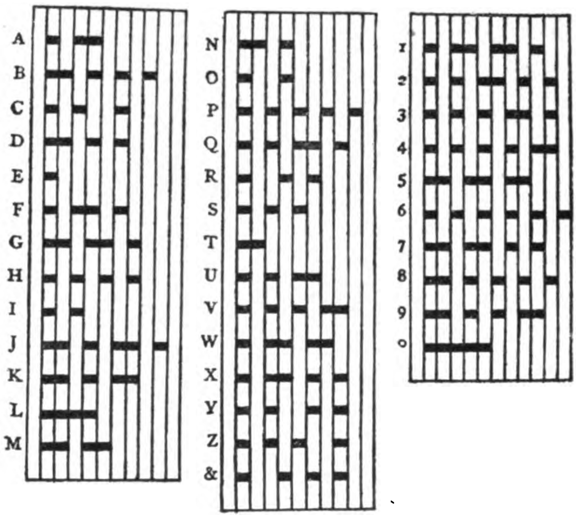
Make dots with the key at uniform and regular intervals, until they can be produced with the precision of a machine and of definite and uniform dimensions.

Next make dashes, first at the rate of about one per second, which speed may be increased by degrees, as skill is acquired by practice, to three per second. Make the space interval between successive dashes as short as possible. If the upward movement which forms the space be made full, it can not be made too quickly.

The third principle occurs but once, and needs no specific directions.

The fourth principle will be found somewhat more difficult to execute. The usual tendency is to make T too long and L too short. Theoretically, the cipher is one-half longer than L, but in fact it is always made the same,

as the practice has been found to occasion no inconvenience. Occurring alone or among other letters, it is translated as L, but when found among figures it is read as 0.



Alphabet and numerals

The fifth principle forms the letter A. The usual tendency is to separate the two elements too much.

The dash followed by a dot (N) is usually found to be somewhat difficult. Time the movement by pronouncing the word ninety, sounding the first syllable fully. Guard especially against the usual tendency to separate the elements by too great a space.

Having become thoroughly familiar with the principles, the following exercises may with advantage be taken up in order:

E	I	S	H	P	6
.	..	...	....	.....	......

These should be practiced repeatedly until the correct number of dots in each character can be certainly made at every trial. A habit once formed of making the wrong number, usually one or two too many in the case of H, P, and 6, is almost impossible to eradicate. Guard especially against the objectionable habit of shortening or clipping the final dot, a vice which leads to innumerable and vexatious errors and misreading of signals.

T	M	5	¶
—	— —	— — —	— — — —

The faults to guard against particularly in this exercise are shortening or elongating the terminal dash, and separating the successive dashes by too great a space interval.

A	U	V	4
- —	- - —	- - - —	- - - - —

The usual tendency to allow too much space between the dot and dash in the above letters may be overcome by forming them as by an elongation of the final dot in I, S, H, and P.

I	A	S	U	H	V
- -	- —	- - -	- - —	- - - -	- - - —

Practice these characters in pairs, that the distinction between them may be more firmly impressed upon the mind.

N	D	B	8
— -	— - -	— - - -	— - - - -

The student who has mastered the sixth principle will find no difficulty with the above characters.

A	F	X	,
- —	- — -	- — - -	- — - —

W	1
- — —	- — — -

U	Q	2	Period
- - —	- - — -	- - — - -	- - — — - -

3
- - - — -

These are similar to preceding exercises, and present no new difficulties.

K	J	9	7
— - —	— - — -	— - - —	— — - -

J and K are usually considered the most difficult letters in the code. Avoid the tendency to separate J by a space into double N, and be careful that the dashes are of equal length. The numerals 7 and 9 require some care to insure correct spacing.

O	R	&	C
- -	- - -	- - - -	- - -

Z	Y
- - - -	- - - -

These are termed the space letters, and the utmost care and diligent practice are necessary in order to form them accurately. The ability to transmit the spaced letters with absolute correctness is the test of a strictly first-class sender. The space should be just enough in excess of that ordinarily used between the elements of a letter to enable the letters intended to be made to be distinguished with certainty from I, S and H. The most usual tendency is to make the space too great, even in some cases as great as the space between letters. This is a most fruitful source of misapprehension and error, and too much pains cannot be taken to acquire and maintain correct habits in this particular.

Methods of Practice

In transmitting words containing groups of two or more spaced letters, careful operators are accustomed to slightly increase the spacing between successive letters of the group.

The receiving operator adds to the message after it is received the month and year and, after satisfying himself that the checked number of words corresponds, gives "R" followed by the call letter of his station and his own personal signal.* The operator then enters in the proper places at the head of the blank call letter of his own station, with his personal signal and the time the message was received.

Communications transmitted by telegraph or signals are always confidential and are revealed only to those officially entitled to receive them.

When several messages are to be sent in succession "end of message" signal is made after the signature of each, to be followed by the abbreviation "ahr," meaning "another," after which the sending of the next message is begun.

No message is considered sent until its receipt has been acknowledged by the receiving station.

Practice in transmission from miscellaneous manuscript is strongly recommended. The ability to read all kinds of copy—good, bad, and indifferent—correctly at sight is a most valuable one, and it is not difficult to acquire by attention and experience.

If the principles here laid down be firmly adhered to, the learner will find much reason for encouragement not only at the rapidity with which he will master what at first sight appears to be a very difficult undertaking, but the extreme accuracy with which he will be able to manipulate his instrument after a fair amount of practice.

This art can only be acquired by constant and persevering practice, keeping in mind the principles given above.

In learning to read by sound, it is advisable for two persons to practice together, taking turns at reading and writing, and each correcting the faults of the other. The sounds of the code characters must first be learned separately and then short words chosen, which must be written very slowly and distinctly and well spaced, the speed of manipulation being gradually increased as the student becomes more proficient in reading.

When the operator has made sufficient progress, he will be given instruction in checking messages, the conduct of offices, the care, adjustment, and repair of instruments.

Checking the Message

In preparing the "check" of the message, all words and figures written in the address, body of the message, and the signature will be counted. That is, count all words after *to* to the end of the signature. The word "sig." is sent merely to indicate that the signature follows, and is not counted in the check.

In counting the check of a message, all words, whether in plain English, code, or cipher, pronounceable or unpronounceable, or initial letters, will be counted each as one word. The abbreviations for the names of places, cities, towns, villages, States, Territories, and Provinces will be counted as if written in full. In the names of towns, counties, countries, or States all of the words will be counted.

Abbreviations of weights and measures in common use and cardinal points of the compass will be counted each as one word.

Figures, decimal points, and bars of division, and letters will be counted each separately as one word.

In ordinal numbers, the affixes st, d, nd, rd, and th will each be counted as one word.

* On military telegraph lines, short cables, and field lines the receipt of a message is acknowledged by the signal "OK."

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

CHAPTER V

BEFORE we start with the Dead Reckoning problems, a chapter will be devoted to the important knowledge of the rule of the road, or how to handle the ship in order to avoid danger of collision. Every navigator should be thoroughly familiar with this. We have also included other helpful and important regulations.

RULES OF THE ROAD

Lights, Fog Signals, Whistles, Etc.

Regulation Lights Should be Exhibited from Sunset to Sunrise

Lights for an Ocean Steamer Under Way

On the starboard side a green light; on the port side a red light, and a white masthead light. The side lights are fitted with inboard screens projecting three feet forward of the light, so that they cannot be seen across the bows. They show from right ahead to two points abaft the beam on their respective sides. The size of the glasses must be six by six inches, and these lights must be visible for at least two miles on a clear night. The masthead light must be carried on or in front of the foremast, not less than 20 feet above the deck; but if the beam of the vessel exceeds twenty feet, it must be carried at a height above the hull of not less than such beam. It must show from right ahead to two points abaft the beam on each side, and must be seen for five miles on a clear night.

A steam vessel when under way may carry an after light of the same character as the masthead light described, which shall be fifteen feet higher than the masthead light.

Lights for a Sailing Vessel Under Way

The same character of side lights as prescribed for a steamer, but she shall carry no other lights.

Lights for a Towing Vessel

The side and masthead lights, and in addition an extra masthead light, six feet below the other, but in the same line. If towing more than one vessel, she shall carry an additional white light six feet below or above the others if the length of the tow, measuring from the stern of the towing vessel to the stern of the vessel being towed exceeds 600 feet. This third light must not be carried less than fourteen feet above the deck. The towing vessel may carry a small white light abaft the funnel or aftermast, for the vessel towed to steer by, but such light must not be visible forward of the beam.

Lights for a Vessel at Anchor

A vessel under 150 feet in length shall carry forward where it can be seen, at a height not more than twenty feet above the hull, a white light so con-

structed as to show a clear and unbroken light all around the horizon at a distance of at least one mile; but if the vessel exceeds 150 feet in length, she shall carry at a height of not less than twenty and not more than forty feet above the hull, such a light as just described, and at or near the stern of the vessel, another such light not less than fifteen feet lower than the forward light.

Fog Signals for a Steamer Underway

A prolonged blast of the steam whistle at intervals not to exceed two minutes.

Fog Signals for a Sailing Vessel Underway

When on the starboard tack one long blast of the fog horn; when on the port tack, two long blasts of the fog horn; when running with the wind abaft the beam, three blasts of the fog horn.

Fog Signal for a Steamer Towing Another

One long and two short blasts.

Fog Signals for a Vessel at Anchor

Ringing the ship's bell rapidly for five seconds at intervals not to exceed one minute.

The Law About the Size of Running and Anchor Lights

The glass in the side lights shall not be less than 6 inches wide and 6 inches high. The glass globe of the anchor light shall be not less than 8 inches in diameter, which is equal to 24 inches in circumference. There is no law prescribed for the size of the masthead light, but it is provided that it must be of such character as to be visible for five miles on a clear night.

Lights and Shapes Shown by Vessels Not Under Command

A vessel which from any accident or cause is not under command shall show by night, well above the deck, where they can be seen all around the horizon for a distance of at least two miles, two red lights shown over one another, not less than six feet apart. By day, both sail and steam vessels not under command shall show two black balls or shapes, each two feet in diameter, one over the other, not less than six feet apart, and hoisted well above the deck where they may be seen all around the horizon.

Lights for a Vessel When Aground in a Fairway

A vessel aground at night on or near a fairway shall carry the prescribed anchor light or lights and two red lights where they can be best seen, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles. In the daytime, however, there shall be carried in a vertical line one over the other, not less than six feet apart, two black balls or shapes each two feet in diameter.

Signals for a Vessel Laying or Picking Up a Telegraph Cable

A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as a steam vessel's masthead light, and if a steam

vessel in lieu of that light, three lights in a vertical line one over the other not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light white, and they shall be of such a character as to be visible all around the horizon, at a distance of at least two miles. By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, three shapes not less than two feet in diameter, of which the highest and lowest shall be globular in shape and red in color, and the middle one diamond in shape, and white. When such vessel is not making way through the water, she shall not carry side-lights, but when making way shall carry them.

Rules of the Road for Inland Waters

Inland water vessels are governed by the pilot rules prescribed for those waters. When ocean steam vessels enter pilotage waters, they are governed by the rules provided for said pilotage waters, and not by the rules of the road at sea. These rules may be had at the office or at the Local Inspectors.

Stem Light

A bright white light is carried in front of the stem by steamboats, tugs, and other mastless steam craft, navigating rivers and inland waters in general. This stem light must show from right ahead to two points abaft the beam on each side, and must be seen two miles.

Range Light

A seagoing steam vessel, when under way, may carry an additional white light similar to the masthead light. These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other, that the lower light shall be forward of the upper one. The vertical distance between these two lights shall be less than the horizontal distance.

All steam vessels (except seagoing vessels and ferry boats) shall carry, in addition to the red and green side lights, a central range of two white lights; the after light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The head light shall be so constructed as to show an unbroken light through twenty points of the compass, namely, from right ahead to two points abaft the beam on either side of the vessel, and the after light so as to show all around the horizon.

A vessel, when towing another vessel shall, in addition to its side lights, carry two bright white lights in a vertical line, one over the other, not less than three feet apart, and, when towing more than one vessel, shall carry an additional bright white light, three feet above or below such lights, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds 600 feet. Each of these lights shall be of the same construction and character and shall be carried in the same position as the steamer's masthead light or the after range light.

Such steam vessels may carry a small white light abaft the funnel or aftermast, for the vessel towed to steer by, but such light shall not be visible forward of the beam.

What Should Be Done When Going Away from a Dock

Blow a prolonged blast of the steam whistle as a warning to other vessels under way in the vicinity.

What Should Be Done Upon Approaching a Bend In a River or Harbor

Blow a prolonged blast of the steam whistle as a warning to other boats that might happen to be coming the same way on the other side of the bend, and slow down engines until the bend is rounded.

In a Fog What Extra Precautions Should Be Taken?

Post a lookout, keep the whistle going, and slow down the engines. If making the land, keep the lead going.

Alarm Whistle

Four short blasts of the steam whistle.

Rule When Two Steamers Are Running In the Same Direction and the One Astern Desires to Pass the One Ahead.

Should the vessel astern desire to pass the one ahead on her right or starboard side, she shall give one short blast of the steam whistle, and if the vessel ahead answers with one blast, then the vessel astern shall put her helm to port, and pass the other.

On the other hand, should the vessel astern desire to pass on the left or port side of the vessel ahead, she shall give two short blasts of the steam whistle, and if the vessel ahead answers with two blasts, then the vessel astern shall put her helm to starboard and pass the other.

If the vessel ahead does not think it safe for the vessel astern to attempt to pass, she shall signify the same by giving several short and rapid blasts of the steam whistle (not less than four), and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as it can be safely done, when the vessel ahead shall signify her willingness by blowing the proper passing signal to the vessel astern.

The vessel ahead shall in no way attempt to cross the bow or crowd upon the course of the passing vessel.

Cross Signaling

Answering one blast with two blasts, or answering two blasts with one blast. Upon receiving such cross signal, blow the alarm whistle consisting of four short blasts.

Rule for Vessels Meeting Obliquely

When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side, shall keep out of the way of the other.

The steamer which has the other on her own port side shall hold her course and speed, and the steamer which has the other on her own starboard side shall keep out of the way of the other by directing her course to starboard so as to cross the stern of the other, or if necessary, she shall slacken

her speed, or stop, or reverse. The steamer which has the other on her own port bow shall blow one blast to show her intention of crossing the bow of the other, holding her course and speed, and said signal shall be promptly answered by the other steamer by one short blast to show her intention to direct her course to starboard so as to cross the other's stern, or otherwise to keep clear. When this cannot be done, the danger signal of four short blasts shall be blown, and both steamers shall be stopped and backed, if necessary, until passing signals are made and agreed upon. This comes under the head of Rule 8.

Rule 9 provides that when two steamers approaching each other at right angles, or obliquely, the steamer having the other on her own starboard side may cross the bow of the other if it may be done without involving risk of collision.

If the steamers are within half a mile of each other, the steamer having the other on her own starboard side shall give as a signal of her intention to cross the bow of the other, two short and distinct blasts, and if this is agreed to, she shall proceed, but if not agreed to by the other steamer the latter shall sound the danger signal of four short blasts, and both steamers shall be stopped and backed if necessary until passing signals are agreed upon.

On What Side of the Channel Are Steamers to Keep?

All steamers must keep to the righthand or starboard side of the channel when it is possible to do so.

How Would You Signify Misunderstanding of Signals?

By several short, quick toots of the steam whistle—not less than four.

Rule When a Steam and a Sail Vessel Approach One Another

A steam vessel is always to keep out of the way of a sail vessel.

Rules for Sailing Vessels Approaching One Another

Risk of collision may be ascertained by watching the compass bearing of an approaching vessel, and if the bearing of same does not appreciably change, such risk should be considered to exist, and one of them shall keep out of the way, as follows:

(a) A vessel running free shall keep out of the way of one close-hauled.

(b) A vessel close-hauled on the port tack shall keep out of the way of a vessel close-hauled on the starboard tack.

(c) When both are running free with the wind on different sides, the vessel having the wind on the port side shall keep out of the way of the other.

(d) When both are running free with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

Signal for a Pilot

At night, a white light flashed above the bulwarks for a minute or so at a time, or by day, the pilot signal S., or the Jack hoisted to the fore.

Signals of Distress

When a vessel is in distress and requires assistance from other vessels (or from the shore) the following signals should be displayed by her, either together or separately:

In the Daytime—A gun, or other explosive signal fired at intervals of about a minute.

The International Code Signal of Distress indicated by "N. C."

The Distant Signal, consisting of a square flag, having either above or below it a ball, or anything resembling a ball.

A continuous sounding with any fog signal apparatus.

In the Night Time—A gun or other explosive signal fired at intervals of about a minute.

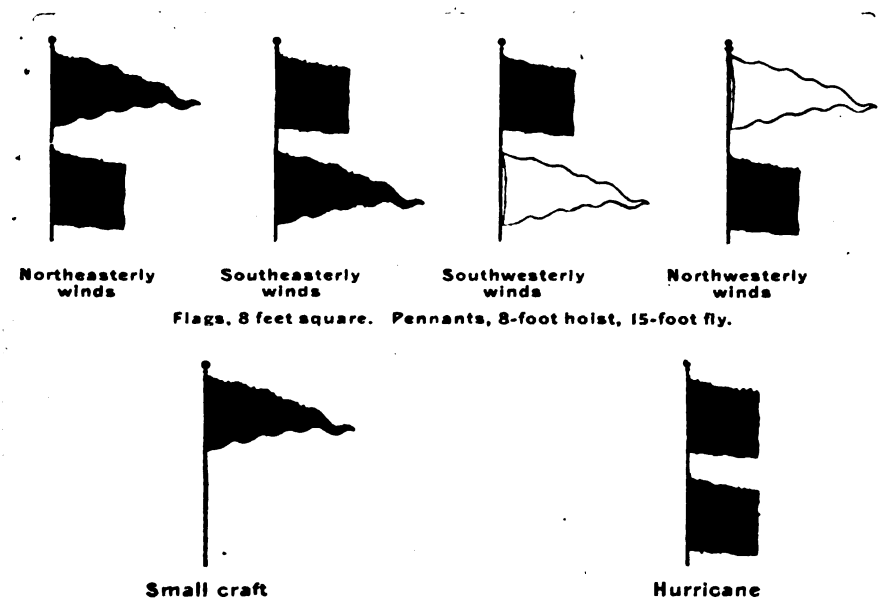
Flames on the vessel (as from a burning tar or oil barrel, etc.)

Rockets or shells, throwing stars of any color or description, fired one at a time at short intervals.

A continuous sounding with any fog signal apparatus. A blue light burned every few minutes.

SMALL CRAFT, STORM, AND HURRICANE WARNINGS

Storm



In the illustrations above the color red is indicated by the shaded portions

Storm Warning Signals

Small Craft Warning—A red flag with a black center indicates that a storm of marked violence is expected. The pennants displayed with the flags indicate the direction of the wind; red, easterly; white, westerly. The pennant above the flag indicates that the wind is expected to blow from northerly quadrants; below, from southerly quadrants.

By night a red light indicates easterly winds, and a white light below a red light, westerly winds.

Hurricane Warning—Two red flags with black centers displayed one above the other, indicate the expected approach of a tropical hurricane, or one of those extremely severe and dangerous storms which occasionally originate in the West Indies or Gulf region and move northward along the Atlantic coastline.

Neither small craft nor hurricane warnings are displayed at night.

Life-Saving Signals

1. Upon discovery of a wreck by night, the life-saving force will burn a red pyrotechnic light, or a red rocket, signifying, "You are seen; assistance will be given as soon as possible."

2. A red flag waved on shore by day, or a red light, red rocket, or red Roman candle at night, will signify, "Haul away."

3. A white flag waved on shore by day, or a white light swung back and forth, or a white rocket or white Roman candle at night, will signify, "Slack away."

4. Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify, "Do not attempt to land in your own boats; it is impossible."

5. A man on shore beckoning by day, or two torches burning near together by night will signify, "This is the best place to land."

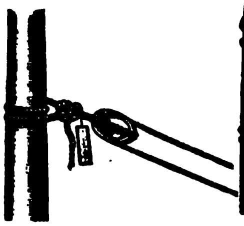


Fig. A—Tail block with endless line fastened to mast

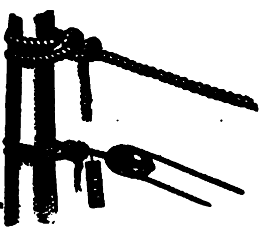


Fig. B—Hawser made fast above the tail block

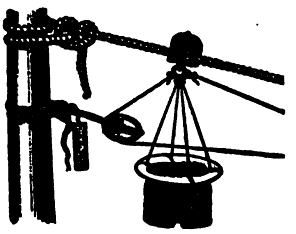


Fig. C—Showing manner of rigging a breeches buoy

Use of the Gun and Rocket Apparatus and Breeches Buoy

If your vessel is stranded and a shot with a small line is fired over it, get hold of the line and haul on board until you get a tail-block with an endless line rove through it; make the tail-block fast to the lower mast, well up, or in the event the masts are gone, to the best place to be found; cast off small shot line, see that rope in block runs freely and make a signal to shore (Fig. A).

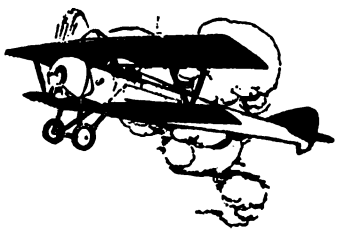
A hawser will be bent to the endless line on shore and hauled off to your ship by the life-saving crew. Make hawser fast about two feet above the tail-block and unbend hawser from endless line. See that rope in block runs freely and show signal to shore (Fig. B).

Life-savers on shore will then set hawser taut and by means of the endless line haul off to your ship a breeches buoy (Fig. C).

Let one man get clear into the breeches buoy, thrusting his legs through the breeches; make a signal to shore as before, and he will be hauled ashore by the life-savers and the empty buoy returned to the ship.

How to Become an Aviator

The Ninth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

OWING to the unusual conditions of wartime it is almost impossible to determine in advance what the outcome of plans will be one month hence. Thus, in the March issue it was announced for this series that the April installment would continue the study of aviation engines, dealing with carburetion and ignition. Demands upon the writer's time which have since arisen, however, made it impossible to complete the drawings for this subject before the magazine went to press, so the opportunity is taken to supply in this general article the answers to many questions which have been submitted by readers. These, in general, have been of the look-ahead type, from men who anticipate becoming flight officers and, as students of the magazine course, are curious to know the later conditions of flight training. It seems advisable to cover this subject in a general way at this juncture, if only for the reason that it will make the reader realize how important is careful study of the preliminary knowledge represented by this magazine course.

The most familiar question is that of physical qualification. The best answer to this is that the U. S. Army wants for its air service, men that are physically perfect. This is true of all nations, and, as long as the supply of perfect men lasts, the rigidity of examination is not likely to slacken. The medical tests for air pilots are thorough and skillful, little doubt remaining at the end of the examination of an applicant's fitness. Sight is tested, hearing, and sense of balance. The condition of the nervous system is accurately determined; digestion and respiration must be first class, and the circulatory system approved. Certain mental qualifications are also desired, a mind developed by a college education or its equivalent in experience being preferred.

For non-flying service, that is, the men behind the pilot, the physical requirements are not quite so drastic. The service rendered by these men and the distinctions of duty between both flying and non-flying crews of the Signal Corps will now be explained.

THE FLYING CREW

An aeroplane's flying crew is largely governed by the type of machine. Small machines of high power, designed either for strategic reconnaissance flights or pursuit at high speeds, carry but a single aviator. The two-seater, or most common, aeroplane carries an observer or gunner. Aircraft of the super-plane class carry from 3 to 15 men, comprising additional duties of navigator, gunner, engineer and radio operator.

THE NAVIGATOR

Military control and direction of pilot gunners, bombers, radio operator and engineers, as well as the navigation of the machine in flight, is the duty of the navigator, usually the senior officer of the crew.

THE PILOT

Management of the controls of the aeroplane while in flight is the duty of the pilot. He is also responsible for final inspection of the craft before the flight is begun, and for the careful completion of any repairs or alterations on the machine. Immediately upon return from a flight it is his duty to examine minutely all controls, lifting surfaces and braces and supervise all mechanical adjustments not included in shop work.

THE OBSERVER

Preparation of reconnaissance maps and reports, all observations and computations of flight navigation is the duty of the observer. In combat he directs the fire against enemy aeroplanes and, if on a bombing expedition, orders the use of explosive or incendiary bombs according to objective. He is also responsible for the efficiency of the personnel of the crew and the material.

MOTOR ENGINEER

Uninterrupted operation of the motor or motors in flight is the responsibility fixed on the motor engineer. At all times he performs, with the help of an assistant, any work necessary to insure the highest operating efficiency of the aeroplane's engines, and is responsible for all repairs other than those required to be made in the machine shop.

THE GUNNER

Expertness in the care and operation of machine guns and the construction and operation of explosive and incendiary bombs is required of the gunner. Range-finding, loading and releasing devices for bombs and barometer, telescope and air compressor must also be thoroughly mastered.

RADIO OPERATOR

Installation of apparatus, assembly and dismantling of radio equipment, thorough knowledge of all codes of army signaling are qualifications of the radio operator. In addition, he is responsible for all communications from the aeroplane and must be familiar with the operation of visual signaling devices, such as the Very pistol, rockets, smoke bombs, etc.

THE REPAIR CREW

Two non-commissioned officers and three privates, first class, are generally assigned to an aeroplane and are responsible for its care on the ground. In the case of small aeroplanes the repair crew may consist of only three men, but the general practice is a crew of five.

AVIATION MECHANICIAN

The chief of the repair crew is rated first class sergeant or sergeant, and in the U. S. Army is known as Aviation Mechanician. He is responsible for the condition of the aeroplane and its material while it is in the hangar; he supervises all adjustments, alterations, installations and repairs. All property issued for maintenance and all tools and accessories are in his charge, and he is responsible for the cleaning and preservation of the aeroplane.

ASSISTANT CHIEF OF CREW

Rated as a sergeant or a corporal, the assistant aids the chief and is required to be a qualified mechanic capable of discharging all duties of the chief of crew.

MECHANICIAN HELPERS

The three mechanician helpers, rated as privates, first class, are under the orders of the chief of crew and his assistant. They are required to assist in adjustments, alterations, removals, installations and repairs, to clean the motor and all parts of the aeroplane fusilage and surfaces, fittings and fixtures, wires and cables. It is their duty to keep the hangars clean at all times; to replace tools and equipment; to elevate the machine on chocks or jacks when in its stall and to cover the motor propellers and cockpit. Hauling gasoline, oil and other supplies and assisting in repair work are among their duties. When not employed about the machine they are required to be available for instruction or duty in the machine and repair shop.

INSTRUCTION IN FLYING

Candidates for instruction in aviation in the U. S. Army are selected from the following sources:

Officers of the line of the Army, '
Enlisted men of the Aviation Section, Signal Corps,
Civilian aviators, employed as Instructors,
Civilian aviators, employed to perform flying duties and given the rank of Aviator, U. S. Army,
Officers and enlisted men of the Signal Officers and Signal Enlisted Reserve Corps.

THE FLYING COURSE

The instruction is divided into definite stages comprising a complete flying course, as follows:

(a) Preparatory.
(b) Preliminary.
(c) Elementary.
(d) Advanced.

The preparatory instruction includes all the teaching up to the point where the pupil actually takes hold of the controls while the craft is in flight through the air. Preliminary training may be defined as the instruction up to the point where the student makes a flight alone, making quarter, half or full turns. Elementary training is the stage of instruction preliminary to the completion of pilot's tests. Advanced flying is the next step up to the qualification tests as a junior military aviator.

JUNIOR MILITARY AVIATOR TESTS

(a) Five figures-8 around pylons, keeping all parts of the machine inside of a circle, with radius of 300 feet.

(b) Climb out of a field 1,200x900 feet and attain 500 feet altitude, keeping all parts of the machine inside of the field during climb.

(c) Climb 3,000 feet, kill motor, spiral down, changing direction of spiral, that is from left to right and land within 150 feet of a previously designated mark.

(d) Land with dead motor in a field 800x100 feet, assuming the field to be surrounded by a 10-foot obstacle.

(e) From 500 feet altitude, land within 100 feet of a previously designated point, with a dead motor.

(f) Cross-country triangular flight of approximately 60 miles without landing.

(g) Straightaway cross-country flight, without landing, of about 90 miles.

FLYING BY DUAL CONTROL METHOD

THE AEROPLANE

A machine of moderate power and slow speed is used, with large surfaces for slow landing speed. Dual controls are provided, so that either instructor or student can control the craft.

FIRST STAGE

The student merely observes the operations of the instructor at the beginning. He is given the "feel" of the air and taught to gauge, by the air pressure against face and body, his speed and flotation for horizontal flight, climbing and banking. The machine's response to the controls are noted and their resistance to motion observed.

SECOND STAGE

Instruction is given in the operation and management of the controls. Horizontal flights are followed by broad, flat turns, quarter, half and full circles to right and left, simple, normal landings and float-offs and balancing the aeroplane in the air. Flight through unfavorable, disturbed air is next performed, including banking, climbing and gliding, moderate spiral glides and straight and spiral volplanes. Landings of various kinds are then taught, including normal, slow-speed, pancake and stall landings, and the landings in wind. The instructor gradually turns over the air controls to the student as the instruction progresses, and finally the power controls. Taxying, or maneuvering the machine on the ground, is also mastered before the student takes to the air alone.

FLYING ALONE

Detailed instructions as to the flight course and maneuvers to be performed, are given by the instructor before the student flies alone, and the altitude is also prescribed. The first flight alone is elementary, being restricted to horizontal flight, getaways and landings on a straight course. It is followed by adding circles to right and left, moderate climbs and straight glides. Figures eight are made with gradually decreasing radii and steeper banking; the turns are then combined with glides and advanced to spiral glides. From both straight and spiral glides, landings are then made with a dead motor. The instructor watches his pupil closely from an observation tower during these flights and corrects all faults observed at the completion of the flight.

FLIGHT INSTRUCTION BY SOLO METHOD

FIRST AEROPLANE

The first machine used for this method, practically one of self-training by progressive use of selected aeroplanes, is low powered with small lifting surfaces, in fact not intended for use off the ground. The speed of propeller revolution is limited by a stop on the engine throttle. The student first learns the manipulation of controls from the pilot's seat, that is, the rudder, elevators and balancing planes, or ailerons. He is then taught to "taxi" on the ground, using a straightaway course on a broad, flat and hard path, and to acquire skill in steering the machine on the ground.

SECOND AEROPLANE

The next machine is one of limited power but designed to lift off the ground for a height of about two feet, the lift being regulated by the throttle of the engine. The limitation of power causes the machine to sink gently back on the ground but permits the student to master the operation of the elevator. Hops up to 200 feet are made in this way and the handling of balancing planes is accurately learned. From then on the machine is regulated gradually until straightaway flight is made at heights up to 20 feet, several take-offs and landings being required with each flight.

THIRD AEROPLANE

The next machine is of an advanced type and in it flights are made at an altitude of 50 feet, at which very slight curves are taken along the course. Increasing altitudes are attained and these curves are gradually advanced to circles, with greater angle of banking for decreased radius or increased speed; these are mastered by barely perceptible degrees. Broad figures of eight follow and straight and spiral glides under throttled power advance to glides without power, or the volplane. Accuracy in landing on a mark and coming to rest over a mark are then attained.

Combination of Training Methods

Where time permits, the best training course is a combination of solo and dual methods, the former to give the student self-reliance and the dual control instruction to correct any errors acquired in training.

MILITARY AVIATOR COURSE

Advanced flying is begun with training designed to perfect judgment in landings and the volplane. Difficult conditions are then imposed, the flyer being taught to handle his machine near buildings, fences and all classes of obstructions, first on the ground and then in the air. He is trained to use and land over imaginary obstacles or over a specified height, indicated by a string stretched between two posts and marked by a pennant. He ascends from and descends into fields of restricted area, marked by chalk lines for safety.

High-powered machines and unfavorable weather are selected and sharp turns, steep banks, spiral glides and difficult landings are practiced. The instruction is mainly designed to give the pilot confidence in his abilities and to impress upon him caution and thoroughness.

The elementary observer's course follows. This consists of progressive flights at increasing altitudes and under varying conditions of visibility, from clear weather to foul. Visibility tests with naked eye and field glasses of various powers are made, followed by instruction flights in reconnaissance and navigation of the air. Short cross-country flights in preparation for junior military aviator tests are then in order.

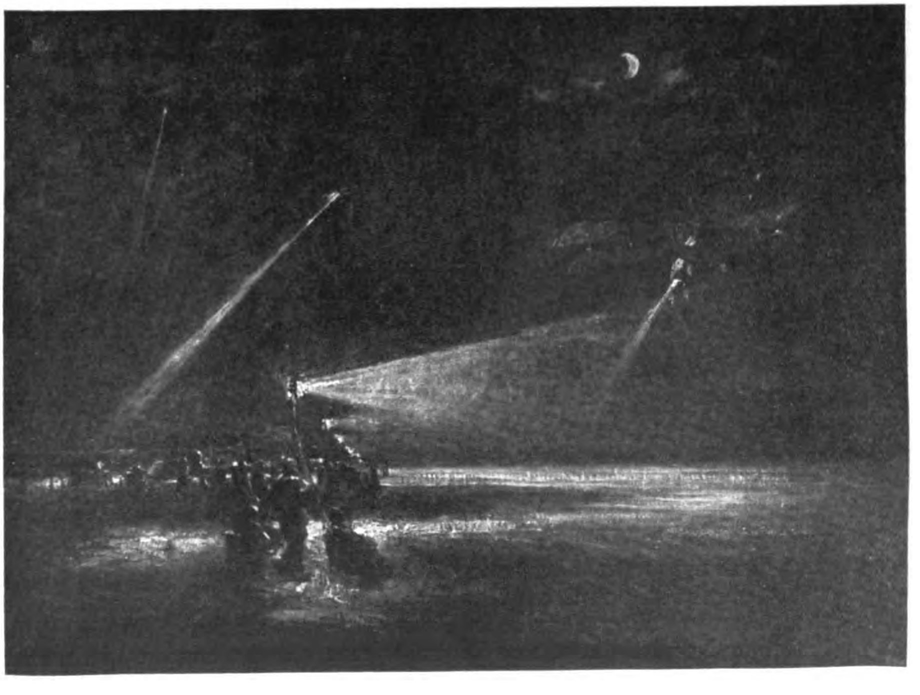
These tests complete the training as a military pilot; further development is acquired by training on various types up to super-planes and high speed pursuit planes. Expert aviators are required to attain a minimum altitude of 12,000 feet, remain in flight for four hours and cover 200 miles, cross-country.

ADVANCED FLYING

The advanced work is classified by the Training Department of the Army Aviation School into special phases as follows:

Excessive use of controls
Reduced power flights
Flat glides
Steep climb
Banking up to 90°
Fast landings and get-aways
Landing across wind
Stalls, side-slips, tail-slides, loops
Bad weather; rain
Water flying
Night flying
Altitude flights; duration flights; cross-country flights
Passenger carrying and low flying

The course of study and practical work embraces the elements of aeronautical engineering, use of meteorological and aeronautic instruments; advanced meteorology; practical reconnaissance; spotting artillery fire; bomb dropping; principles of aerial combat; wireless telegraphy; gunnery; strategic and tactical employment and administrative control of the air squadron.



This reproduction of a painting by Lieut. Farré of a bombardment by night shows powerful searchlights lighting up the ground of the field of aviation, thus permitting the machines to land safely

MILITARY AIRMEN

MAJOR FRANK PURDY LAHM

Pioneer aeronaut has been associated with the Wright Brothers and is a prominent member of the Aero Club. He has also seen extensive service in the U. S. Army in connection with dirigible and spherical balloons and airplanes.

NO name is more familiar in connection with the early aeronautic work of the United States Government than that of Major Frank Purdy Lahm. From his father, Frank S. Lahm, he has doubtless inherited his talent for the science of aviation, and his fearlessness as a pilot. The elder Lahm was one of the founders of the Aero Club of America, and for many years the Dean of the air pilots of the Aero Club of France. As a special commissioner for the Aero Club of France he investigated the early claims of the Wright Brothers.

Major Lahm followed in his father's footsteps, and while stationed at West Point in 1906 arranged for the first balloon flight for members of the Aero Club. He continued to be very active in the interest of aeronautics in America. Accompanied by Major Hersey he won the first Gordon Bennett International Balloon Race held in Paris in 1906, bringing the trophy to America. The Lahm Trophy, for the pilot making the longest flight in America, was subsequently won by Allan R. Hawley who made the record flight from St. Louis of 1,172 miles.

In 1908 Major Lahm was selected by General James Allen, then in command of the Signal Corps of the U. S. Army, to be trained by Orville Wright to fly the Wright aeroplane, the first heavier than air machine purchased by the Government. The day following Wright's famous flight of one hour and two minutes, which established a world's record, Mr. Wright invited Major Lahm to accompany him on a voyage aloft. The major, dressed in boots and spurs, dismounted from his horse and climbed into the machine beside Mr. Wright, thus making the first passenger flight in America.

Major Lahm later operated the first dirigible balloon owned by the United States Army. After service in France he was stationed in the Philippines and later at North Island, San Diego, where he was engaged in training military aviators. He was later transferred to the United States Balloon School at Fort Omaha, Neb. He is one of the few aviators who hold all three of the certificates issued by the Aero Club of America; he has the Dirigible and Spherical Balloon Pilot's, and an Aviation certificate which was the second to be issued.

Signal Corps Has Opening For Many Electrical Men

They Are Required for Various Branches of Radio Communication Work

THE Signal Corps, U. S. Army, has announced that it can use the services of a large number of men having electrical training.

They are needed especially in connection with the radio communication systems in use in the military service.

All classes of electrical men—wiremen, expert electricians, storage battery men, telegraph and wireless operators, and men with electrical engineering training and experience are wanted. The opportunity offered is exceptional because of the great interest and importance of this branch of the service, most aptly characterized as the nerve system of the army.

Men engaged in the radio division of the communication work in particular have an increasingly important part in the great intelligence system upon which army operations are almost totally dependent. The scope of this work requires men who will fall in general into three classes, depending on the character and amount of experience had by the individual; namely, radio operators, radio mechanics and field radio experts.

Application blanks for service in the radio work of the Signal Corps may be secured by addressing the Office of the Chief Signal Officer, Land Division, Training Section, Washington, D. C. Men of draft age may make application, and if qualified, will be inducted into the army, at their request, for service in this branch of the Signal Corps.

After enlistment or induction, all personnel will be sent to one of several radio schools for six weeks to three months of intensive training in one of the three general branches of the radio work for which their previous experience qualifies them.

Some of the personnel completing these courses will be commissioned, and the opportunity for advancement for all graduates will be dependent on the individual ability.

A Combination Set

This article describes a combination wireless telegraph and telephone set which, while it admits of a wide range of adjustment, is compact and more efficient than the average amateur set. In fact, with this set, communication was established between New York City and Port Washington, Long Island in broad daylight, using a simple three-electrode valve at the receiving station. As a wireless telephone set, it will transmit a fraction of a mile, provided a very short gap and low condenser capacity are employed.

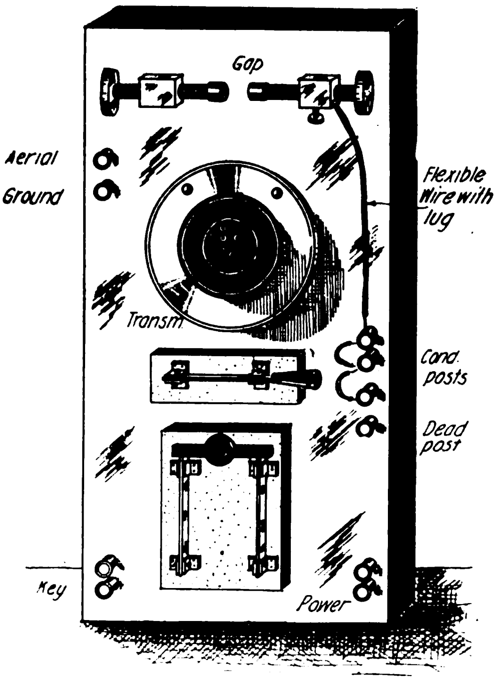


Figure 1—Combination set

The cabinet is made of any close-grained hard wood, preferably mahogany, but if bakelite is procurable, it will be more satisfactory. In Figure 1 the coil is placed in an upright position in a corner, with three sections of high tension condenser placed beside it, each section having a capacity of .001 microfarad. The individual sections consist of eleven glass plates, 2 inches by 5 inches, coated with tinfoil 1¼ by 4 inches. These are bound with tape, and while they may seem rather small, they have sufficient capacity for a 1 or 2-inch coil.

The spark gap is placed on the top of the panel and directly underneath it, an ordinary telephone transmitter. In order to cut this transmitter out of the circuit a single-pole, single-throw switch is shunted around it. At the bottom of the board a d. p. s. t. knife-switch controls the primary circuit. One end of each of the three high tension condensers are connected together, and to one terminal of the coil. The remaining three condenser terminals are connected to binding posts on the right side of the panel, to which connection is made from the right hand terminal of the spark gap by means of a flexible wire. The terminal is provided with a lug. The capacity of the condenser is varied by connecting one or more of the posts with the wire from the spark gap.

Heavy stranded wire or copper ribbon should by all means be employed for connecting up the circuits of radio-frequency. I have found automobile high tension cable ideal for a small set of this size.

In the diagram the aerial binding posts are placed at the upper left hand corner of the panel, the posts for the key at the lower left hand corner, and the source of power is connected to posts at the lower right hand corner.

To improve the appearance of the set two or three coats of black asphaltum varnish should be applied to the cabinet. The back should be made removable to permit of adjustment of the vibrator. Since the dimensions can vary considerably, none have been given in this article.

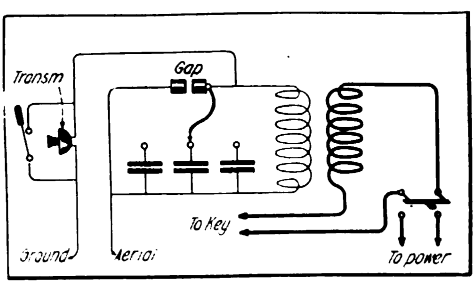
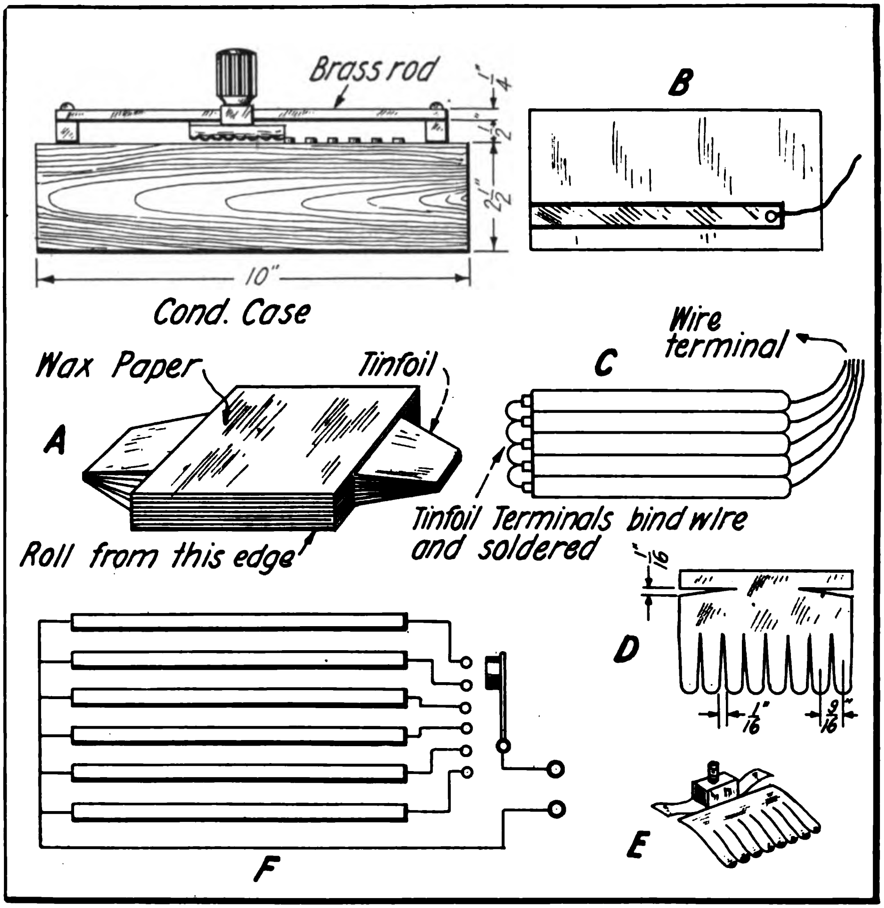


Figure 2—Circuit diagram

This apparatus will not act as a wireless telephone transmitter unless an arc is produced at the spark gap, and the gap must therefore be very short and must



Details of the adjustable fixed condenser

be shunted by the smallest possible capacity. In fact, it has been found advantageous to insert a series condenser in the antenna circuit to reduce the absorption of energy from the spark gap circuit. This will decrease the wavelength, but it will be much easier to obtain the arc at the gap which is strictly necessary for the manipulation of this apparatus. A diagram of connections is shown in Figure 2, in which the position of the transmitter is clearly shown.

J. W. HALLIGAN, *New York.*

Editorial Note.—Unless the antenna used with this set is exceedingly small, we are inclined to believe that even when used as a telegraph transmitter, better results would be obtained by the elimination of the shunt condenser capacity and in the event that this condenser is necessary in order to secure an oscillatory discharge, an oscillation transformer and a standard closed oscillation circuit would give the best results.

The Construction of an Adjustable Fixed Condenser

This is a description of a simple method of constructing an adjustable condenser which, although it will not entirely take the place of an air dielectric condenser, has sufficient fineness of variation of capacity to permit it to be used across the secondary winding of a receiving transformer.

The accompanying drawing shows the construction in detail and also the method of connecting up the apparatus. The condenser is made of wax paper and tinfoil. Connections are brought out from several sheets to the point of a multipoint switch which is constructed like the sliding rod of a receiving tuner.

To begin the construction, cut thirty-three pieces of wax paper, 3 inches by

3 inches, and eight pieces, 4½ inches by 4½ inches. Next cut twenty-six pieces of tinfoil, 2 inches by 3 inches. Make one condenser of five pieces of tinfoil and seven of three pieces of tinfoil. The units are assembled by laying one piece of paper on the tinfoil and so on. The tinfoil, it will be noted, laps ½ inch over the wax paper at both ends.

After this is done the condensers are rolled from one side as shown at A. Two advantages are derived from this: (1) the condenser is compact; (2) on account of the thickness of the tinfoil, it is much easier to solder the connections.

After the rolled condenser is complete it should then be bound and a wire soldered to one of the tinfoil lugs. Next wrap the condenser in one of the large pieces of wax paper as indicated at B, leaving one of the lugs unwrapped. Bind the unwrapped lugs together with a wire and solder a lead to them.

A switch must now be constructed for connection with the various tap-offs. The blade of the switch, as will be noted, is of spring sheet brass, cut as shown at D. The size of the switch will vary according to the size of the contact in use.

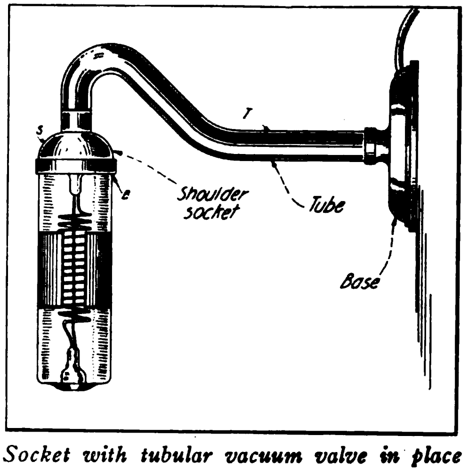
The switch is soldered to the bottom of a square brass tube as shown at E. This tube is ¼-inch square and ½-inch in length. A battery terminal is soldered to the top of the tube; this may be taken from an old dry cell. A hard rubber rod is next fitted as shown. The slider rod is a piece of brass, ¼-inch by ¼-inch, and 9 inches in length. The case is 10 inches in length, 5 inches in width and 2½ inches in height. It may be made from any wood at hand. The two supports for the slider rods are ½-inch by 2 inches at the base and ½-inch at the top. It should be at least ½-inch in height. A complete diagram of connections is shown at F.

If required, a much larger condenser can be made along the same lines. It is, of course, understood that this condenser is only suitable for receiving apparatus and cannot be used in connection with the transmitter, but it is a very handy piece of equipment at a receiving station because it permits tuning and adjustment which cannot be accomplished by an ordinary fixed condenser.

Lloyd Wolfe, *California.*

A Socket for a Tubular Vacuum Valve Bulb

This is a description of a socket for use with a tubular vacuum valve bulb that did good service in my station until war broke out. So far I have not noticed in The Wireless Age any reference to such a holder. As is well known, the ordinary tubular vacuum valve bulb is rather difficult to fasten in place during use, and, furthermore, the wires leading to the internal elements are apt to break off at any time because they are generally used to support the bulb.



Socket with tubular vacuum valve in place

After the wires have been led through the tube, T, the bulb should be drawn tight into the socket, S, by pulling tightly on the wires. It should then be held over a candle flame. The melted sealing wax is then poured around the bulb at B and allowed to cool. It will then be found that the bulb is thoroughly held in place and will withstand considerable strain before it will become free.

E. M., *New Jersey.*

A Digest of Electrical Progress

Effect of the War Upon Telegraph and Telephone Industries—Union of Power Companies—The Government's Searchlight Regiment—The Merits of The Metric System—The Telephone and the World War

Effect of the War Upon Telegraph and Telephone Industries

IN a recent issue of the "Electrical World" a writer reviews the effect of the war on our methods of communication. He declares that on the whole the wire and cable lines are carrying on "business as usual," but precedence is given to the immensely increased Government traffic. Telephone companies have been compelled to employ retired operators to take the places of those who have given their services to the Army and Navy. Additional women employees have been placed in operating, clerical, and supervisory positions formerly occupied by men. Through the use of automatic transmitters, messages may be dispatched by untrained clerks at a message speed greater than that obtained by the best Morse operators.

The writer mentions the extension of women's work into positions formerly held almost exclusively by men. He states that telephone companies have always had a large number of women employees, but in common with many other industries they have not been fully cognizant of the availability of women for positions requiring long and technical training. It is not generally known that the complicated mathematical operations involved in wire transmission and other problems are now worked out largely by women who specialized in mathematics at college. Continuing, the writer remarks:

> The telegraph systems of the country have become more heavily loaded in at least two ways—(1) because of the growing need for quick communication which results from the large amount of wartime production, and (2) on account of the daily increasing delays in the mails, which, of course, enforces larger use of telegraphic messages. On the other hand, telegraphic traffic is cut down by the natural stimulus to economy which accompanies uncertain financial conditions and also by the increased urgency which in many instances necessitates telephonic communication, even at increased

cost. Just how these several factors will finally affect the general traffic load cannot be determined until detailed message reports are available, but it seems likely that a marked growth in telegraph business, and especially that of the "night letter" classification, will be found.

In spite of the careful plans laid down by commercial telephone companies, long distance telephony has suffered since the beginning of the war. On account of their value to the Government communication, so many of the trained operators have entered the Signal Corps and Naval Communication departments that the telephone companies are actually handicapped. Message service is made poorer than in the past, but this is probably accounted for by the fact that the lines are overcrowded due to the enormous pressure to which they have been subjected by war business. Telephone instruments have been called for in such large quantities that companies have been forced to refuse to extend many private installations. It has been necessary to inject into the service a large number of inexperienced girls and this naturally increases the confusion and delay even though superhuman efforts are being made by the companies to offset this.

Regarding the changes in the wireless telegraph field, the writer remarks:

> War conditions have brought great changes in the commercial wireless-telegraph field . . . all commercial shore stations were closed by order of the President immediately after the United States entered the war. This put a stop to actual and anticipated international and overland radio traffic. Wireless outfits were permitted to remain in operation on shipboard as a matter of safety to passengers and cargos, but communication has been limited strictly to necessary position reports, warnings and similar maritime matters, all of which are sent in cipher. The Navy Department maintains a chain of land wireless stations along the shores of the country and has extended its services to comprehend essential commercial radio traffic, but since this must be entirely subordinated to governmental affairs the total number of private messages is extremely small.

In taking over the cargo ships, the Government has taken control of the operation of the radio apparatus. Hundreds of vessels are now entirely in the hands of the Naval radio service as regards the inspection and maintenance of their radio apparatus, and the supply of operators for them. Wireless companies have largely become manufacturers for the Army and Navy, and the development of new inventions is directed almost entirely toward their utility in war work.

Due to uncertainty in trans-Atlantic mails, the essential close co-operation between our Government and those of the European Allies and the diversion of long distance wireless stations for military uses, the traffic on the cables has mightily increased. Stringent censorship regulations have been adopted. To date nothing abnormal has been reported in the way of interruption because of the scarcity of enemy raiders left at large, and viewed in its entirety, the cable business seems to have suffered little change. Certain technical advances, including the use of selenium and other relays, have been made. No particularly sensational improvements have been announced.

Regarding the future of commercial radio, the writer remarks that "it seems to be dependent largely upon its general technical development, and consequently the present period of military domination must be looked upon as a necessary set-back resulting from the availability of wireless communication as a weapon. When the great war is won and conditions are more normal again, the useful future of radio signaling will come into sight once more, and the newest of the communication arts should progress rapidly to its fullest development."

We disagree with the writer to some extent on the latter statement. We do not see that the war has in any way hindered the general technical development of radio, although naturally the increase of commercial stations has been effected. Numerous technical problems have been solved and inventions have been made that will permit commercial operation over greater distances than were heretofore considered possible. One of the good effects of the war has been the standardization of apparatus and the design of equipment, which is more flexible and better suited to commercial operation than that heretofore employed. The results which wireless radio engineers have gained through the construction of special apparatus for the requirements of the Government are bound to benefit the commercial side of the art. Opportunities are granted commercial companies to engage in research work such as never before, and at the close of this war, some of the inventions which will be made public will excel the dreams of those who are not in close touch with the situation.

Nothing has been left undone by our Government to put into service the best equipment available at this date, and whenever a rearrangement or re-design of the apparatus proved of ultimate benefit, changes were effected immediately. The thousands of wireless sets furnished to the Government and the experience of several thousand operators having charge of such equipment will stimulate and enhance the progress of the art in every possible way.

Union of Power Companies

AFTER joint conferences of the State Fuel Administrator Schwabacher and the California Railroad Commission, it was decided by the Pacific Coast Electric Company, the Great Western Power Company, the Sierra and San Francisco Power Company, and the Universal Electric and Gas Company, to operate their systems under one management. Under this plan, several stand-by plants can be shut down without endangering continuity of service. By operating only those centrally located stand-by plants whose efficiency is highest, a great saving of fuel will be effected and loads will be distributed so that the water storage in hydro-electric developments can be used to maximum advantage.

The combined systems furnish power over an area of about 40,000 square miles which is believed to be the largest area under the administration of a single management. The total generating capacity is about 3,771,600 kw. 240,000 kw. is generated by hydro-electric plants and the remainder by steam plants. A careful observer of the plan has recently commented in the "Electrical World" on the new arrangement as follows:

> The consolidation of central California power systems for joint operation as a war measure is one of the long strides forward which are made from time to time in the West. It is not often, however, that so important a move is made literally overnight or is launched without precedent largely on faith that all concerned will do their part fairly. Much credit is due the several companies for the spirit shown in joining competitors without hesitation or limitation. The redistribution of load, it is understood, is to be made by one man, Mr. Downing, without let or hindrance, the determining factor always being the efficiency of the several systems considered as one unit and the minimum consumption of fuel.
>
> One of the most important features of the move and one which there has not yet been time to work out in detail is the apportionment of income under the combined plan of operation. However, with all concerned in a

co-operative rather than a competitive attitude, it will be simply a matter of agreeing upon that plan which seems fairest to all. With the rainfall in California thus far the least in sixty-nine years, a plan which contemplates utilizing water storage more efficiently cannot impair the interests of stockholders. No man could be found who has better qualifications than Mr. Downing as "power dictator" for the California systems. Not only does his experience eminently qualify him to handle the complex problems of this work but he has the complete confidence of the several companies involved. The success of the plan under his administration may well establish a precedent that will be far-reaching in effect.

The Government's Searchlight Regiment

THE War Department is organizing a regiment of searchlight companies for special service in France. These units will be highly specialized and used for battle illumination and anti-aircraft protection. The companies will be armed and equipped as regular military units and will form part of the regular army organization. They will be called upon for extremely active work in the war zone and only those specially qualified for such work will receive consideration.

The plan is to obtain bright, young, intelligent, and ambitious men who possess a fundamental knowledge of mechanics and electricity, as well as trained and experienced electricians, gas engine operators, and machinists. The enlisted personnel will embrace men experienced in one or more of the following occupations: Electricians, gas-engine operators, machinists, motor-truck drivers, blacksmiths, horseshoers, mechanics and general all-around utility men.

Men must first enlist as privates and will be paid $30 per month, together with food, clothing, medical attention, etc. Non-commissioned grades will be available at rates of pay from $36 to $96 per month. Further promotion is open to those of ability.

The work in which these young men will engage in the war zone embraces the following:

To discover and keep in touch with the movements of the enemy during the night.

To seek out and illuminate hostile objectives, so as to fire upon them.

To blind the enemy.

To periodically illuminate roads and possible hostile positions in the more distant foreground by the light.

To search the near foreground.

To support fire effect by illumination of hostile targets.

To disturb hostile works by alternate blinding and turning on the beam or by working the beam back and forth.

To blind opposing searchlights.

To support attacks in the foreground by throwing the beam in front of the advancing troops and screening their movements.

To reveal obstacles to their own artillery, which is thus enabled to destroy them.

To blind the enemy and disturb his forward march and firing capacity and confuse him by making him think his plans are discovered.

To facilitate the landing of aviators at night.

For anti-aircraft work and night-bombing defense.

Complete information may be obtained by writing directly to the Commanding Officer, Fifty-sixth United States Engineers, Washington Barracks, D. C.

The applicant must give (1) name, (2) address, (3) age, (4) married or single, (5) nationality, (6) whether he will enlist for the period of the war,

(7) brief statement of education, (8) present occupation, (9) experience, (10) name and address of present or former employer, (11) whether or not the applicant has been drafted.

In special cases, men of proper experience who already have been drafted in the service may be transferred.

The Merits of the Metric System

THE pros and cons of the metric system of weights and measures were discussed at the January 23rd meeting of the American Institute of Electrical Engineers section at Lynn, Mass. Among the speakers were L. D. Burlingame, Industrial Superintendent of the Brown & Sharpe Manufacturing Company; S. S. Dale, editor-in-chief of Textiles, and Professor A. E. Kennelly, of Harvard University. In the absence of Professor Adams, Professor Kennelly spoke twice, and he remarked that the adoption of the metric system is making some progress in the art of electrical engineering. He admitted that a complete change to the system would take time and cost money, but he urged that the United States, Great Britain, and Russia fall into line and adopt it as soon as convenient so that there would be an international system.

Mr. Burlingame contended that endless confusion would be caused in his business by the compulsory adoption of the metric system of measurements. Mr. Dale told of an amusing record of one day's training by a Chilean family. In Chile the attempt to standardize the metric system has been a long and baffling effort.

Mr. F. T. Cox, Chairman for the evening, advised all to continue to ponder over the merits and demerits of the system as pointed out by the debaters of the evening.

The Telephone and the World War

"THE Telephone and the World War," was the subject of a most interesting talk delivered before the members of the New York Electrical Society on January 24th by H. J. Carroll, of the New York Telephone Company. One of the instructive points upon which the speaker went into detail was the manner in which the barrage fire is regulated by men known as "linking officers" in the British Army. These officers push on after the infantry advance, laying wires, and then telephoning back to battery commanders the location of the enemy, at the same time advising the distance to which the fires should be shifted to be effective. To protect these wires all the warring armies maintain telephone patrols which constantly test, repair, and protect the line.

Men who possess abnormally acute olfactory senses are stationed as observers for approaching gas attacks. Upon scenting attack these men stationed at outposts telephone the alarm to the trenches permitting the soldiers to don their protective masks before the gas arrives. The speaker also described a very sensitive instrument for locating tunnelling and digging by the enemy hundreds of yards away. He spoke in detail about the use of the telephone in the field by the Russians, French, and Austrians; also he told how the Anzac troops had constructed at the Dardanelles a telephone central station the walls and ceiling of which were made entirely of sandbags. He stated that 12,000 competent telephone operators are employed by the American army in France with the special duty of handling Government messages throughout the United States. The entire organization of the Army under General Pershing is connected by telephone from sea ports to the front line trenches. He mentioned that the telephone had in some respects proved superior to the telegraph owing to the rapidity at which orders could be given.

Wireless Music For Wounded Soldiers

By Albert Marple

BEFORE a great while the boys of the U. S. Army in France who are injured while doing their "bit," will be persuaded to forget their aches and pains along with all the hardships ot war, by strains of music, carried to them by wireless. It is planned that they will hear novels and poetry and news stories, the soldier boy who is too ill even for a little entertainment not being disturbed, for the entertainment will be distributed in individual doses by wireless telephone and phonograph.

Through the generosity of the Ebell Club of Los Angeles, the first set of this wireless phonograph has been purchased for $1,000; it is to be donated at an early date to the American Base Hospital in France. The outfit will consist of a transmitting set, along with fifty portable or hospital receiving sets, for use on fifty different beds. By placing one of these sets between two beds and equipping it with two receivers, each receiving set may be made to bring joy and relief to a pair of our wounded fighting men. The sets may be detached from any bed in a moment and carried for use to some other part of the room or building.

As a rule the conditions of the various patients in a hospital prevent the playing of a phonograph. The music, while beneficial to some, would be very irritating to others. This difficulty is overcome by the wireless phonograph.

The sending apparatus is located within a sound-tight room somewhere within the hospital and the attendant to operate the device has only to start the phonograph and throw a switch. From the phonograph the music travels by wire to the wireless telephone transmitter, from which it passes in the form of electrical waves to the sending aerial, going from this point out into space.

The receiving apparatus consists of a light, sensitive telephone receiver which is connected by a silk cord to a metal or wooden case three inches wide, six inches long and four inches

(Continued on page 593)

The wireless set showing phonograph and transmitter

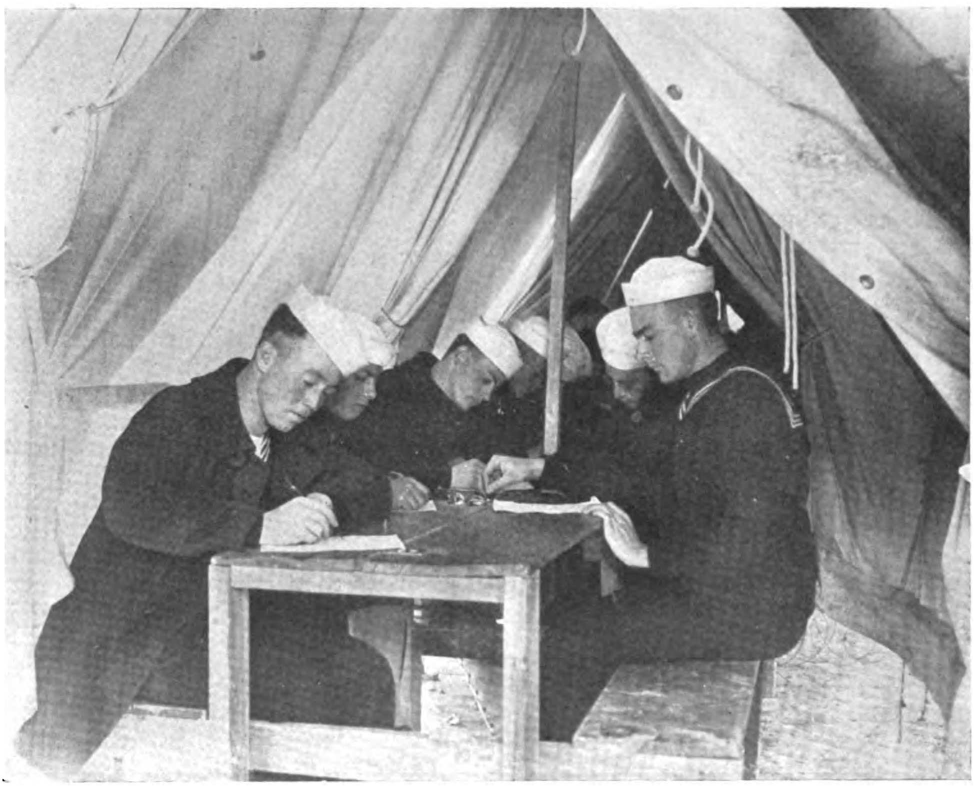
Patient in hospital listening to music by wireless phone

Radio in the Navy

RADIO is a branch of Navy service about which there clings a glamour of mystery and romance which is fascinating to thousands of young Americans who are eager to take an active part in the sea engagements with German war vessels. And there is no more certain way to get under fire with the Navy than to enlist in the radio department.

There is room right now for one thousand more young, ambitious American youths in naval radio. Men who enlisted in other departments of the Navy are now transferring to radio in ever greater numbers.

A man who qualifies as a radio operator soon becomes the envy of the ship; his superior officers are dependent upon him and usually are eager to watch him send messages. In no other branch of the service is such an opportunity provided for experimental and research work and the exercise of initiative. In the case of those who are sent to the United States Naval Training Station, Great Lakes, Illinois, a course of several weeks is given the recruits, who then are sent to Harvard University for additional training. Yet even with these inducements and advantages recruiting offi-



Beginners at the Great Lakes Naval Training Station specialize on code practice, instruction being given in both Morse and Continental

cers cannot secure enough radio men.

The biggest radio training station in the country is at Great Lakes, Illinois, thirty miles north of Chicago. Captain William A. Moffett is commandant. The district is in charge of Lieutenant A. Hoyt Taylor, district communication superintendent, and includes sixteen stations. Radio gunner M. B. West is assistant communication superintendent. Lieut. L. C. Dent is in charge of the stations at Milwaukee, Wis.; Manitowoc, Wis.; Frankfort, Mich., and Ludington, Mich. Lieut. F. H. Mason, whose headquarters are at Cleveland, has charge of Detroit, Mich., and Buffalo, New York. Lieut. Mark Frazer is in charge of Calumet and Duluth and has headquarters at Minneapolis, Minn. All of these men are familiar figures to readers of The Wireless Age. Commodore C. G. Bowman, U.S.N. (Ret.) supervises the territory included by Mackinac, Alpena, Mich., Sheboygan, Drummond Island and Manistique, where his headquarters are located. All are under the supervision of Captain Moffett and Lieut. Taylor.

The Great Lakes station is equipped with a powerful transmitter which makes possible communication with either coast and the Darien station in the Panama Canal Zone. NAJ, a call familiar to all operators on the Great Lakes, is sounded before a daily report of storm warnings, and other necessary information is sent out.

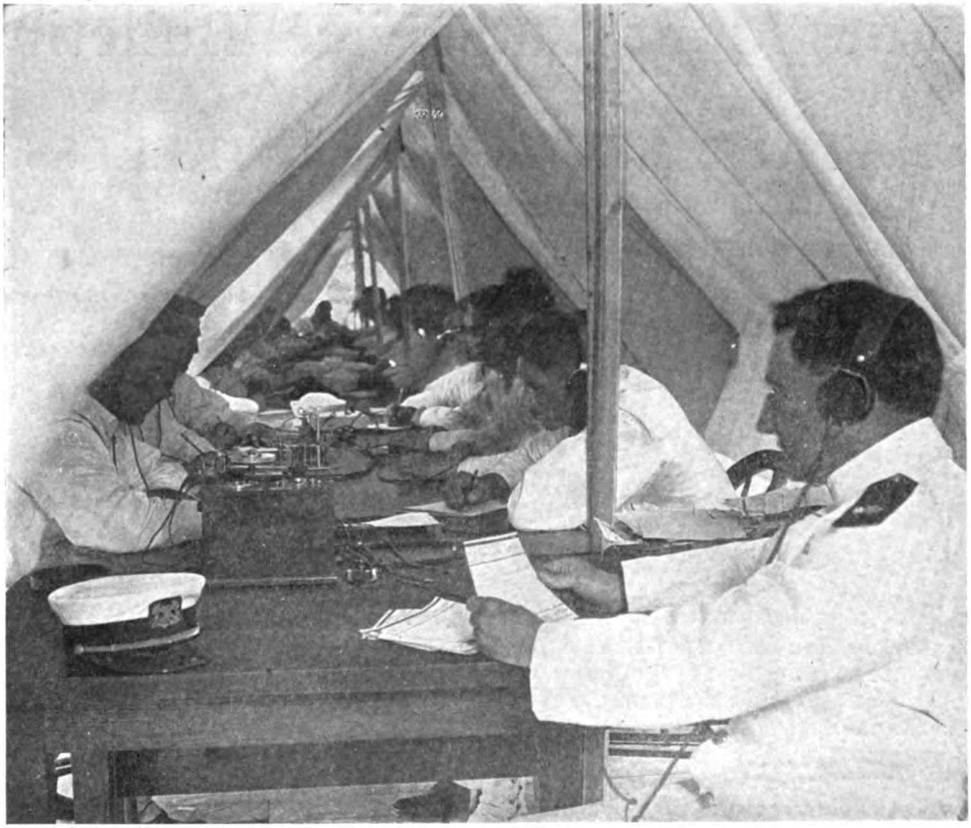
Five hundred students, among whom are all the prospective aviators, attend the radio school daily at Great Lakes. The elementary course of instruction is given in three months to inexperienced radio students. Some of the men who have had some experience with amateur stations complete the course in considerably less than the allotted time. Upon finishing the work at Great Lakes, embryo radio operators are sent to Harvard University, where the Naval Reserve Radio School is located. Here they complete their training and from here they are detailed to ships on the high seas.

Psychology is used in conducting the radio courses. Students are taught

Captain William A. Moffett, commandant, under whose direction 500 students a day are prepared for sea service

to speed up in the Morse and Continental codes. A long row of tents adjacent to the radio station serves for the "schoolroom." A recruit's progress is indicated by the tent to which he is assigned. The boys usually have to start in the tent marked "0 to 5"; they soon pass into the "5 to 10" tent. When a student has arrived at the tent marked "20 to 25" his instructors know that he can send at a fairly good speed. When they have completed the courses at Great Lakes and at Harvard the recruits express a preference as to the type of sea service which they wish and then they are detailed to active duty on a battleship, a submarine, shore station, seaplane, or perhaps some merchant ship or transport. The operator's first watch is usually from midnight until 4 a. m. This gives him experience with a regular operator and soon he is allowed to handle a watch of his own.

On ship the radio operator is exempt from coaling duty and most of the other tasks which are considered burdensome by the youths who are



The classrooms are long rows of tents marked 0 *to* 5 *progressively to* 20 *to* 25, *indicating the speed of the recruits in sending and receiving*

anxious to fire a gun at the Germans.

On dreadnaughts he works four hours and then is given eight hours liberty, and in addition he is excused from duty every third day.

The strange thing about it all is that the Navy cannot get men rapidly enough to fill the seats left vacant in the schools when the recruits are sent out to the high seas.

Wireless Music for Wounded Soldiers

(*Continued from page* 590)

high. This case is connected by a tiny wire to the bed post or spring, which constitutes the receiving aerial. After being released by the sending aerial the sound waves travel through space until they are caught by the receiving capacity and transmitted from this by the tiny wire to the receiving cabinet, thence along the silk cord to the telephone receiver, which is held to the ear of the patient.

Another feature of this device is that the phonograph may be disconnected and stories and newspapers may be read to the patients over the wireless telephone.

The transmitting apparatus connected to the phonograph and also to the telephone consists of a group of telephone transmitters arranged in a suitable casting. Being operated on low frequency the waves of this machine are not likely to interfere with or be troubled by the waves of high frequency systems. The system may be operated by a few dry cells, at a cost of not more than ten cents a day in connection with the largest hospital.

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headquarters, 25 Elm St., New York

AT a rough estimate over 50 per cent. of the former amateur experimenters within draft age have enrolled in the Government service. Many under twenty-one years of age have joined the U. S. Navy. Certain members of the association are employed as instructors in Government radio schools; others are assistants in Government research laboratories or are engaged in experimental work in the open field. We can recount three instances in which former amateur experimenters have been placed in charge of important radio development work, but it is necessary to state that they possessed qualifications other than those obtained through home experiments. However, the experience which they obtained as amateur telegraphists gave them an insight into the practical operation of wireless apparatus which otherwise would have required several months of practical training or experience. In other words, the Government received the benefit of the amateur's months of observation of the dispatch of commercial and Government wireless telegraph traffic. Hence, many were fitted at the start to undertake more advanced work.

On account of the confidential nature of the work in which many of the members of the Association are engaged, we are not permitted to speak more in detail, but we have sufficient data on hand to assure us that the Association is well represented in the various Government departments.

* * *

THE U. S. Army needs practical wireless telegraphists, men who can operate equipment, locate trouble, and effect makeshift repairs. Mere theorists are non-essential.

One of the qualifications in certain branches of field signaling is knowledge of gasoline engines. Many former motor enthusiasts will have no difficulty in taking care of such equipment, but we are inclined to believe that others will have to spend many hours in the study of engine mechanisms. Not only must the mechanical features be understood but the electrical mechanism of gasoline engines will require most careful study.

Selected men who have not yet been assigned to cantonments should study the various types of ignition systems employed in connection with gasoline engines, such as the make and break system, the magneto, and the battery and coil system. They should learn how to time an engine, how to grind the valves, and how to adjust carbureters. Sleeve valve and poppet engines should be given consideration. Knowledge of the electric starting and

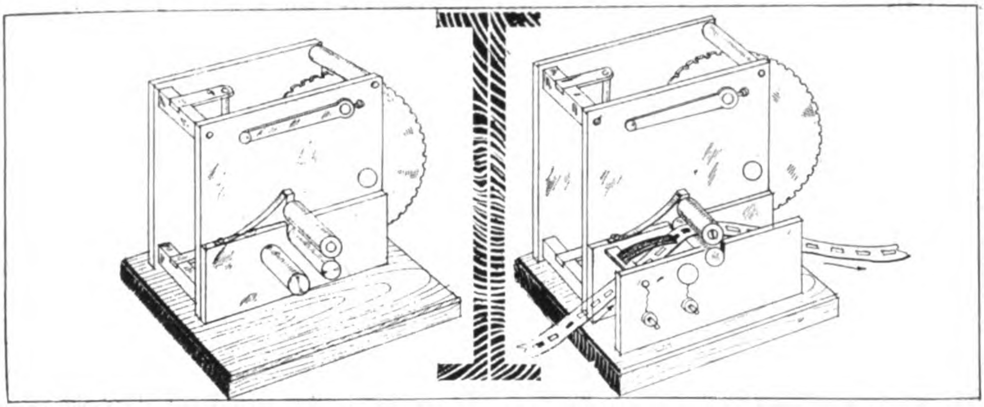


Figure 1 *Second prize article* *Figure* 3

grams show the construction, in general, figure 1 being a detail of the rollers which feed the tape; figure 2, a detail of the tape plunger, and figure 3, the assembled instrument.

The first thing in the order of construction is the purchase of a phonograph motor, preferably one with a square frame. The one I employed was from a standard model B phonograph which is of very simple construction. Next, make the wooden parts. They should be made of hard wood. The base is made ¾″ in thickness and 3″ square. A small bevel is cut around the top edge in order to improve the appearance. The motor is held to the base by means of switch H shown in figure 2. Two machine screws are passed through the holes 6 and 7. The complete dimensions are 4½″ in length, 1½″ in width and ¼″ in thickness, as shown at H, figure 2.

A hole ½″ in diameter should be drilled at 1. A brass tube from ¼″ to ¾″ in diameter serves as the lower contact over which the tape moves. The motor shaft extends through a hole 5, figure 2, which is about ½″ in diameter and ½″ deep. The board, I, is the same size as H and has holes drilled the same size and in the same place as 1 and 5. A hole is drilled at 2 which takes the small machine screws for the brush. Two additional holes are drilled in 3 and 4 for the binding posts.

When these pieces have been completed, piece I should be fastened through the base with wood screws so as to leave a space of about 1½″ as shown in figure 1. Previous to fastening the motor in place take off the small tapered brass bushing at the end of the motor shaft. This ordinarily supports the disc. After you have removed the bushing, cover the motor with a rubber tape so that it will grip code tapes. The motor shaft is indicated at C, figure 1. A rubber roller which presses on the top of the motor shaft, C, is indicated at B, figure 1. These rollers are made of a piece of heavy rubber which may be cut from a hard rubber ball. They should be about ⅝″ in length by ½″ in diameter. A hole could be bored through the center into which is placed a metal bushing, so that it will turn readily.

Make the support for the roller as indicated at A in figure 2. This should be a piece of spring brass or some other elastic metal. This piece is about 2″ in length, ¼″ in width, and it has an end projecting to one side which is ¾″ in length. This is bent down and a hole is drilled to take the bolt on which the roller turns. It is fastened by two nuts. When it is completed fasten it to the wooden support with a wood screw so that the roller comes directly on top of the motor shaft as shown in figure 1. The second support marked H should now be fastened so as to leave a space of ¾″ between it and the first one. Next make the brush shown at F in figure 2. It should be 1″ in length, ¼″ in width, and 1-32″ in thickness. Bore a hole as shown to fasten it to the wooden support. When completed, bend this piece at a right angle at the center. Next solder six No. 22 wires to the end. Each of these wires are approximately 1¾″ in

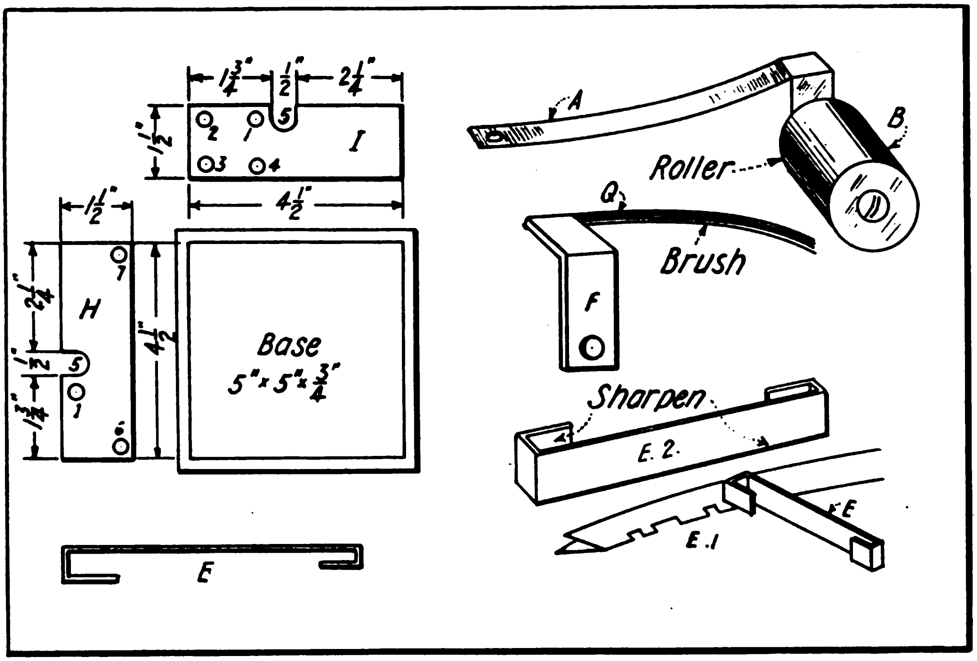


Figure 2—Second prize article

length. Care should be taken to lay them evenly side by side. They make contact with the brass tube, D, through the slots cut in the tape.

A small piece of wire makes connection between the brush and the binding post mounted below it, and another piece connecting the brass tube to the second binding post.

The tapes for this instrument are made by a special cutter as shown at E in figure 2. A small strip of hard metal ¼" in width by 2½" in length is bent in the shape shown so that the inside of the large end measures 3-16" and the inside of the smaller end or dot measures 1-16".

The edges of both the dot and dash ends should be sharpened so as to make the cutting easy. Any paper suitable for the purpose can be employed, but I prefer the black paper which incloses the camera film. I have found it very tough and lasting. This should be cut into tapes about ¾" in width. Just how the dots and dashes are cut is shown in the detail E-1, figure 2, where it will be observed that the tape is folded over and the dots and dashes cut out as shown. These slots may be cut very precisely by hitting the cutter with a small hammer.

Correct spacing of the letters is important. The space between the symbols of a letter is equal to one dot, between two letters is equal to three dots, or, in other words, the width of a dash. The space between two words is equal to five dots.

If this automatic code sender is constructed in accordance with my instructions, it will work satisfactorily and can be operated at a speed of from five to thirty-five words per minute. I would also suggest to the builder that in punching the tape he should use code words rather than ordinary words as better practice is obtained thereby.

Finally, I should mention that with the aid of this sender and the textbook, "Practical Wireless Telegraphy," any amateur should be able to obtain a first commercial license in from two to six months.

Peter M. Hansen, *Chisholm, Minn.*

Try This In Your Spare Hours

Numerous combination detectors have been employed by amateurs in wireless telegraphy and many of them have contained a large variety of elements, but the one shown in the accompanying figures 1 and 2 in respect to the variety of

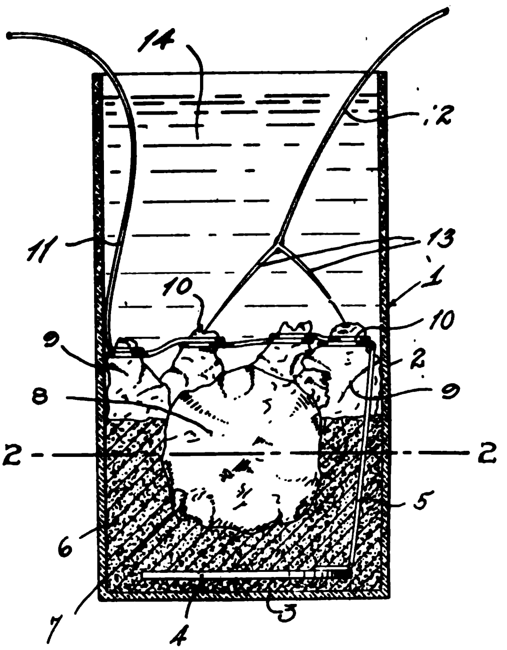


Figure 1—Detector with a variety of elements

elements employed exceeds anything which has so far passed our observation. Evidently, it combines all the good characteristics of well-known rectifiers. In addition, the principle of coherence has been adopted so that one obtains a coherer effect as well as rectification.

In figure 1, a suitable disk, 4, of copper is placed within the jar 1 near the bottom wall and has the wire, 5, which extends upwardly in the manner shown to a point midway between the upper and lower ends of the jar. A suitable filling of carborundum and iron filings, 6 (consisting of one part carborundum and one part iron filings), is placed in the bottom jar and surrounds the plate, 4. This

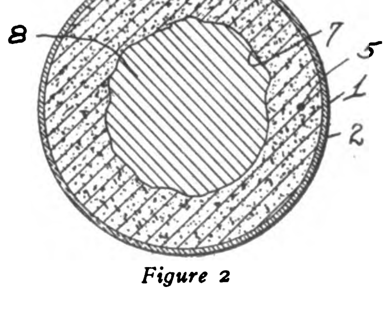


Figure 2

composition fills the jar to a point substantially one-third of its entire height above the bottom, 3, and is provided with a central pocket, 7, in which a suitable silicon crystal, 8, is seated, the upper end of which projects above the upper surface of the composition of iron filings and carborundum. The quantity of silicon is equal to one-half of the two-part mixture of carborundum and iron filings. The upper end of the container is surrounded by a plurality of crystals, 9, of galena, the points of which are disposed upwardly to provide necks around which the wire, 5, is clamped. After the detector has been assembled it is filled with paraffine.

If the experimenter is unable to supply the elements for this detector from his junk shop, he should take his prescription to the nearest drug store or chemical supply house which may be able to supply him with the necessary material! In brief, we have here a combination of metals which we are sure the average amateur has not thought of. We are much interested to learn by what series of experiments the proportionment of silicon to galena, galena to iron, and iron to carborundum was determined.

Preserving Aerial Ropes.

Radio experimenters frequently are annoyed by the breaking of their aerial ropes. Flexible steel cables are too expensive for the average experimenter. A splendid substitute is to buy the best sash cord and boil it in beef tallow for an hour or so. To procure the tallow it is generally necessary to buy beef fat and render out the tallow by heating it over a slow fire. Sometimes it is about as cheap to buy a bundle of genuine tallow candles and melt them. When a good pan of melted tallow is ready, the rope is coiled up and pressed down into the pan and allowed to remain over a slow fire for about an hour. The rope should be punched occasionally with a stick to keep it under the tallow and its position should be changed so that it will not become scorched. A rope thus impregnated will last for years in damp climates.

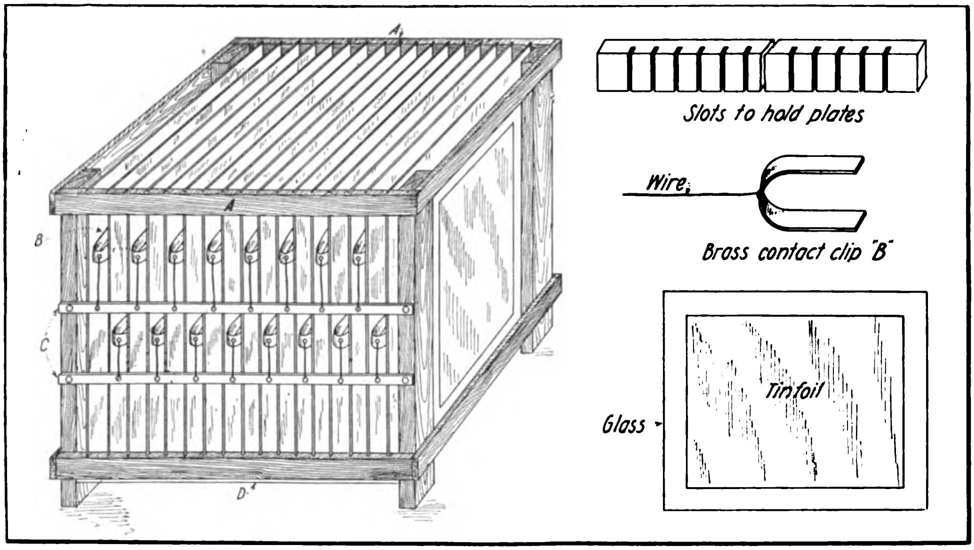


Figure 1 *Figure* 2—*Top* *Figure* 3—*Center* *Figure* 4—*Bottom*

A Useful High Voltage Condenser

To amateurs who desire a high potential condenser with plates that can easily be removed without taking the entire unit apart, I offer the design indicated in figures 1, 2 and 3. If constructed as shown, it will present a neat appearance on a par with the remainder of the apparatus in the complete set.

As shown in figure 1, it consists mainly of a hardwood rack with slotted pieces, A, indicated in figure 2. The slot is made of sufficient width to take the plate with an intervening distance between slots of ½″. A small strip, D, is screwed to A to hold the plate in position at the base.

The plates are coated on both sides with tinfoil, as shown in figure 4, and connections are made to them by the brass contact clip, B, indicated in figure 3. These are in turn connected to the copper strip, C, with binding posts located at each end for connection to the transformer. To prevent brush discharge, the plates should be coated with a good grade of beeswax.

It is evident that the condenser is readily accessible and of more than passable appearance.

A Simple Way to Make a Good Variometer

(*Continued from page* 595)

it back from the ball, pressing the soft wax back around the edges so as to insure proper clearance when the wax is hard.

As soon as the wax is cold, cut the outer layer of cotton tape, carefully unwind the layer if made of cord and then remove all tape. Give the stationary winding which is now held in place another coat of shellac. File a smooth notch in one side of the brass tube at a convenient place in the inside of the ball and run the terminals of the inner winding out through one end of the shaft and mount a suitable knob and pointer on the other end. Then connect up the windings and mount as desired.

This variometer, used in connection with a secondary winding consisting of fifty turns of No. 28 D. C. C. wire wound on a form 3 inches in diameter without taps, will change the wave-length of a circuit from 150 to 500 meters and it is also suitable for use in the wing circuit of the regenerative set shown in the December, 1916, issue of the Bulletin of the National Amateur Wireless Association. M. B. West, *Ohio.*

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

A. B., Orleans, Mass.:

Any attempt to calculate the effective height of the aerial you describe would be more or less conjectural. The form factor of the aerial can be calculated by the formula presented by Mr. Blatterman in the October, 1916, issue of THE WIRELESS AGE, and it may aid you in calculating the radiation characteristics of this aerial. The effective height of the flat top might in your case be considered as an average of the height taken at four to six different points along its entire length.

In the average case the receiving set will respond as well when installed on the second story of a house as if it were on the first floor, particularly if a flat top aerial is employed for receiving.

We cannot undertake to give you a scientific disquisition on the relative sensitiveness of the various types of detectors, but as you are probably aware the vacuum valve detector stands at the head of the list. The cerusite and galena rectifiers probably come next in the order of sensitiveness, followed by the carborundum rectifier. The natural wavelength of the aerial you describe is approximately 465 meters, and it makes no difference whether these wires are connected together at the extreme end or left open.

* * *

P. W., Westchester, Pa.:

Five K. W. transmitting sets are not supplied to the marine service of the Marconi Company. Wiring diagrams and constructional details of this apparatus are not open for publication.

Complete circuit diagrams of the auxiliary storage cell switchboard and connections appear in the book entitled "Practical Wireless Telegraphy."

* * *

A. B., East San Diego, Calif., inquires:

Ques.—(1) If we are permitted to do so after the War, we contemplate erection of an aerial 300 feet in length, 50 feet in height, consisting of four wires spread two feet apart. We intend to use a 1 kw. transformer and rotary spark gap. We are not within five miles of a Government station, and we would like to know (1) if our wave length will exceed 200 meters, and (2) if we would have to get a special permit or would have to reduce the length of the aerial.

Ans.—(1) The radiated wave will undoubtedly exceed 200 meters, and it is doubtful whether or not the Government authorities will permit you to use a longer wave length. An aerial to radiate a 200 meter wave, should not be more than 120 feet in length.

Ques.—(2) We have an inductively coupled receiving transformer the primary of which is 24" in length, 6" in diameter wound with No. 19 wire. The secondary winding is 22" in length, 5" in diameter wound with No. 32 wire. What is the approximate wave length range of this tuner and how far should we be enabled to receive with a crystaloi detector? Could this receiving tuner he employed as an undamped wave tuner? We would much appreciate an answer to these questions.

Ans.—(2) If the secondary coil is shunted by a small condenser, the circuit will respond to waves up to 7,000 meters. The primary winding is rather coarse. Good results would be obtained with a winding of No. 24 S. S. C. wire and a much longer range of wave lengths would be obtained without the use of a loading coil. With the average amateur aerial, you would require some loading inductance in the primary circuit to reach the wave length of 7,000 meters.

We are unable to determine your range with the crystaloi detector, but inasmuch as the majority of long distance stations employ undamped oscillations, you would have to use some type of undamped wave receiver. Page 281 of "Practical Wireless Telegraphy" describes a beat receiver which will suit your requirements. Please be informed that amateurs are not permitted to construct wireless apparatus during the period of the War.

* * *

A. B. R., Moline, Ill., inquires:

Ques.—(1) The capacity of a condenser is often expressed in centimeters. How is this unit derived?

Ans.—(1) The capacity of spherical metallic bodies is found to vary as their radii. Hence the capacity may be expressed in centimeters of an equivalent sphere. In the electrostatic system of notation, a sphere of 1 centimeter radius has unit capacity. A microfarad is the equivalent of 900,000 centimeters capacity in the electrostatic system of units. A farad represents 900,000,000,000 centimeters.

You were enabled to hear the signals from spark stations on your crystal detector previous to the War because of the inequalities in the amplitude of the successive oscillations generated by the arc system. This gives the effect of damping and permits one to receive

signals even with an ordinary crystal rectifier over distances up to 50 or 75 miles.

* * *

E. S., Hoboken, N. J., inquires:

Ques.—(1) Please explain how oscillating currents are produced by an electric arc.

Ans.—(1) The arc gap which is provided with special facilities for cooling electrodes is mounted in a chamber which is fed with hydrogen or illuminating gas. Generally a blow-out magnet is mounted at right angles to the arc. The electrodes are shunted by a condenser and inductance. Assume that the arc gap is open; the condenser connected in parallel to the gap will become charged to the voltage of the direct current supply. When the arc is struck, the voltage of the arc drops. Hence the condenser will discharge through the gap increasing its conductance and causing a still more rapid drop of voltage. When the stored up energy is exhausted, the current will decrease, and owing to the increase of resistance consequent upon the cooling of the gas, the voltage will rise. The condenser will again become charged and the cycle of events will then be repeated.

Replying to your second query, air condensers could be employed provided you had sufficient space for their erection. To obtain the capacity you desire you would require a condenser the surface of one side of which was 3960 square feet. Of course, the condenser could be made up of smaller sections, but nevertheless, it would take up an inordinate amount of space. We are speaking of condensers using air at atmospheric pressure. Compressed air condensers have been employed to some extent but they are cumbersome and difficult to keep airtight. Air at a pressure of 250 pounds is employed as the dielectric.

* * *

G. L. W., New York City, inquires:

Ques.—(1) In anticipation of future use of my wireless receiving set, I wish to have the design of a magnetic coupling coil between the grid and wing circuits of a vacuum valve; in other words, I want to use a tickler coil or small inductive coupler. Are there any special requirements in making this coupler, such as the size of the wire, the number of turns, etc., or is it simply necessary to have an equal amount of wire in each circuit?

Ans.—(1) There is nothing special in the design of these coils. For a long wave length tuner, a loose coupler of the dimensions ordinarily employed for tuners up to 3,000 meters will suffice. If the regenerative coupler is to be used with a short wave tuner, a small coupler such as employed for circuits up to 600 meters fulfills the requirements.

Ques.—(2) I contemplate linking this coupler magnetically with the exciter coil of my set which is wound to tune to a wave length from 200 to 2,500 meters. Would this require any special winding?

Ans.—(2) We do not fully understand the query. Do you intend to use a regenerative coil with a short wave length coupler? If so, the point is covered in the answer to No. 1.

E. S. M., Brooklyn, N. Y., asks:

Ques.—(1) How does the sensitiveness of the Fleming valve compare with that of the audion and the galena detectors?

Ans.—(1) When used in a special circuit, the Fleming valve is equal in sensitiveness to the audion. When used in the ordinary manner the Fleming valve is the most stable in operation of all.

Ques.—(2) Please tell me what my receiving range should be with the following, as shown in sketch:

Three loading coils 12 inches long of No. 20 wire; Murdock loading inductance; Murdock loose coupler; Murdock variable condenser, capacity 0.0005 Mfds.; Clapp-Eastman fixed condenser, capacity 0.003 Mfds.; galena detector; Marconi 2,000-ohm telephones;. Aerial—length, 35 feet; number of wires, 6 of No. 14 B. & S. copper; distance apart, 3 feet; height at lead-in, 70 feet; height at other end, 65 feet; length of lead-in, 35 feet; direction of aerial, East and West; ground wire, connected to water pipe; length, 45 feet.

Ans.—(2) The natural wave length of your aerial is about 162 meters. This may be raised to 4,000 meters in the antenna circuit. The secondary of your receiving tuner, however, does not give the same range of wave lengths. Not knowing the value of inductance for the secondary circuit of the Murdock receiving tuner, we are unable to answer more definitely. The range of your apparatus is approximately 700 or 800 miles at night time; the daylight range is 80 or 90 miles at the most.

Ques.—(3) How much would it increase my receiving range if I were to use a Fleming valve instead of the galena detector?

Ans.—(3) Used in the ordinary manner, the Fleming valve will not increase the range.

Ques.—(4) Does the direction of the aerial make much difference in the receiving range of a set?

Ans.—(4) It makes very little difference except when the flat top portion of the aerial is very much longer than the vertical portion. Under these circumstances directional effects are experienced but not otherwise.

Ques.—(5) Upon what principle does the electrolytic interrupter work?

Ans.—(5) The electrolytic interrupter consists essentially of a plate of lead and a small wire electrode of thin platinum or German silver immersed in a dilute solution of sulphuric acid. The small electrode is generally covered with a glass or porcelain jacket, and is so arranged that more or less of it is exposed to the action of the liquid.

If this interrupter is connected in series with a source of direct current, using the platinum electrode as the anode and the lead plate as the cathode, gases are liberated by electrolysis; the oxygen so produced envelopes the platinum tip and practically insulates it from the solution, whereupon the circuit is interrupted. The circuit being interrupted, there is nothing to sustain the gas bubble, which immediately collapses and again makes the circuit. Thus a great number of breaks are produced per second. If the electrolytic

interrupter is connected in series with the primary winding of the induction coil, the frequency of the spark produced depends upon the area of the platinum point exposed, the self-induction of the coil and the voltage. The average electrolytic interrupter requires at least 60 or 70 volts across it for satisfactory operation.

Book Reviews

Radiodynamics. The Wireless Control of Torpedoes and Other Mechanisms. *By B. F. Miessner.*

The author presents in instructive fashion the most important material concerning the history, methods and apparatus of radiodynamics, the art of controlling distant mechanism without artificial connecting means. The subject matter has been treated in a manner that makes it intelligible to the general reader, without sacrificing the technical exactitude which makes scientific work of value to the trained engineer.

The chief recent developments in this new art have been of a military nature, and for this reason the volume is devoted for the most part to the torpedo-control application of radiodynamics. Beginning with the historical viewpoint of his subject, the author passes on to the wireless control of mechanism, electrostatic and combined induction and electromagnetic wave systems. He treats of the possible control methods for radiodynamics and then discusses the advent of the wirelessly controlled torpedo. A description is given of the work of the Hammond Radio Research Laboratory and a summary of recent developments in the art.

How To Make Low-Pressure Transformers. *By Prof. F. E. Austin.*

This booklet will enable anyone to build a small transformer for experimental purposes at small cost, without the use of expensive tools or machinery, that may be connected with any house

circuit where the pressure is 110 volts or less, and the frequency about 60 cycles. The small transformers, when connected with the ordinary alternating current house circuits, may be used to operate small electric lights, door bells, small arc lights, and direct current toy railroads, operating five or six loaded trains at one time.

The widespread popularity of this booklet has caused this, the third edition, to be published, and it has been greatly enlarged.

Examples In Alternating Currents. Vol. I. *By Prof. F. E. Austin, B.S., E.E.*

The purpose of this book is to assist students who are pursuing courses in electrical engineering, to apply fundamental principles in engineering practice. While the book has been designed to assist the college student, it will be found valuable to those who are pursuing correspondence courses or who are attempting the study of alternating currents by themselves.

The writer states that he has found, as a result of an experience extending over a period of many years, that the average student requires a certain amount of *guidance*, in the solution of engineering problems that are presented to him, and it is the design of this work to furnish such guidance, and at the same time lessen the labor of the teacher.

One feature of the book is the insertion of various tables containing values of variable quantities met with in engineering practice, so arranged as to include a wide range of values, and to render evaluation convenient and rapid.

This is the second edition of the work, and contains additional features in the form of new cuts and subject matter.

The Eyes of the Army and Navy. By Lieut. Albert H. Munday. Cloth binding; 4¾ x 7 inches; 227 pages. Harper's, New York. Price $1.50 net.

This volume is designed to give the student a general knowledge of aeronautical matters, no serious attempt being made to acquaint the reader with the technical considerations of aircraft. The material is therefore unique in its assembly, differing widely from the several hundred books already published on this art.

For instance, the substance of what is taught in aviation ground schools, namely the three broad subjects of theory of flight, construction and care of airplanes, is dismissed in 52 pages, and but 11 pages are devoted to aeronautical engines. Wireless telegraphy is covered in 11 pages of text and 3 illustrative pages. The balance of the book, some 150 pages, deals with many subjects, including map-reading, cross-country flying, charts, meteorology, airplane instruments, semaphore signaling, photography, bomb-dropping, night flying, artillery observation, fighting, and medical supervision.

For the layman who wishes to make a quick survey of the extent of knowledge required of aviators, the volume will be of interest.

Obtainable through the Book Dept., The Wireless Age.

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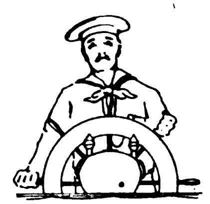

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Weight of Package	Charges Required	Charges Required	Charges Required	Charges Required	Charges Required	Charges Required	Charges Required	Charges Required
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Over 1 lb. up to 2 lbs..	6c	6c	8c	11c	.14	.17	.21	.24
Over 2 lbs. up to 3 lbs..	6c	7c	10c	15c	.20	.25	.31	.36
Over 3 lbs. up to 4 lbs..	7c	8c	12c	19c	.26	.33	.41	.48
Over 4 lbs. up to 5 lbs..	7c	9c	14c	23c	.32	.41	.51	.60
Over 5 lbs. up to 6 lbs..	8c	10c	16c	27c	.38	.49	.61	.72
Over 6 lbs. up to 7 lbs..	8c	11c	18c	31c	.44	.57	.71	.84
Over 7 lbs. up to 8 lbs..	9c	12c	20c	35c	.50	.65	.81	.96
Over 8 lbs. up to 9 lbs..	9c	13c	22c	39c	.56	.73	.91	1.08
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The text matter rapidly leads into more advanced experiments, complete data being given, for instance, for the construction of a wavemeter, and instructions for its use under all conditions. This includes tuning, the measurement of inductance capacity of a wireless telegraph aerial, and general methods of calibration. The measurement of the logarithmic decrement is treated in a way easily understood by the beginner. The design and working drawings for several types of low power transmitters are included, covering the construction of a quenched spark gap and apparatus associated therewith.

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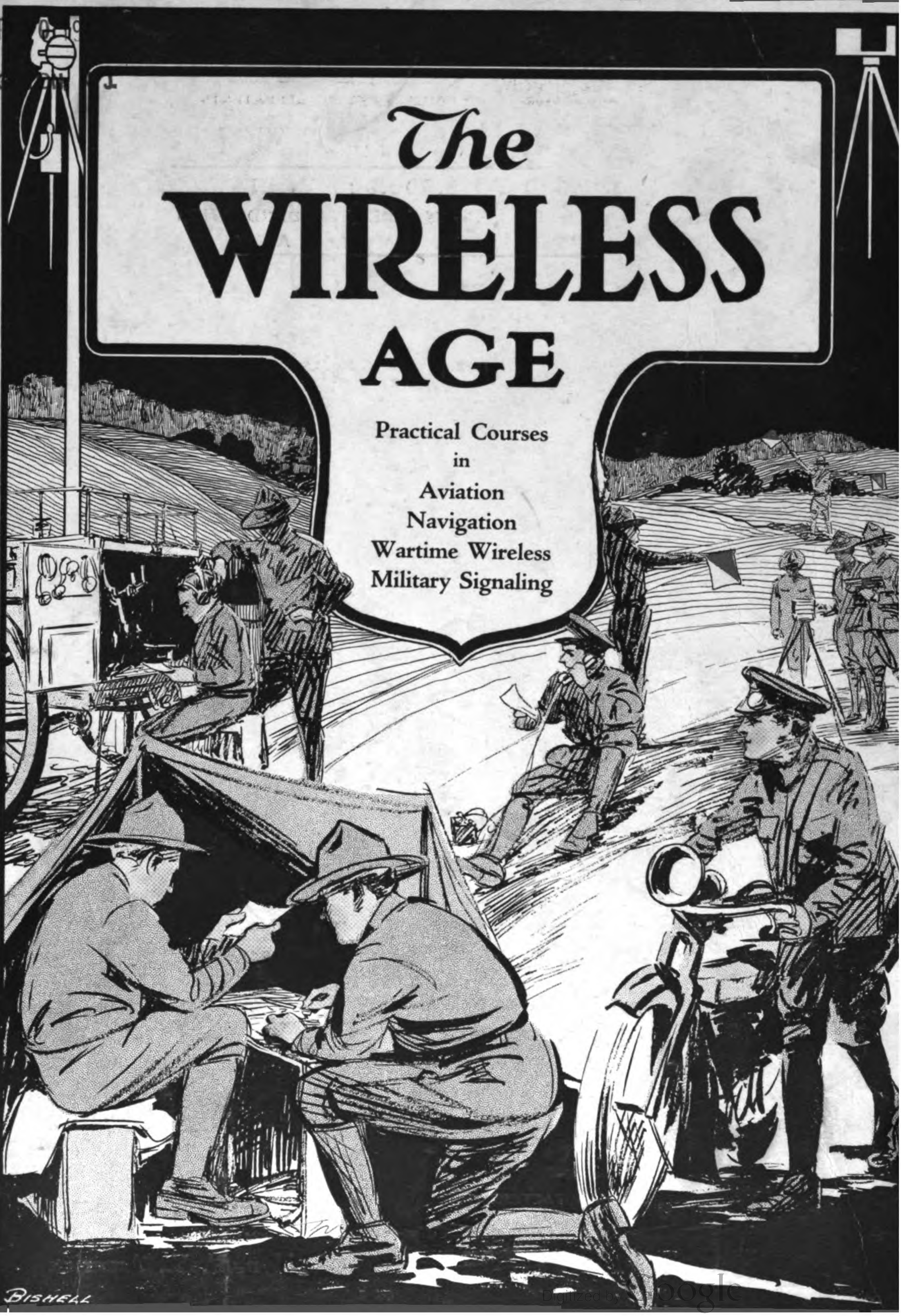
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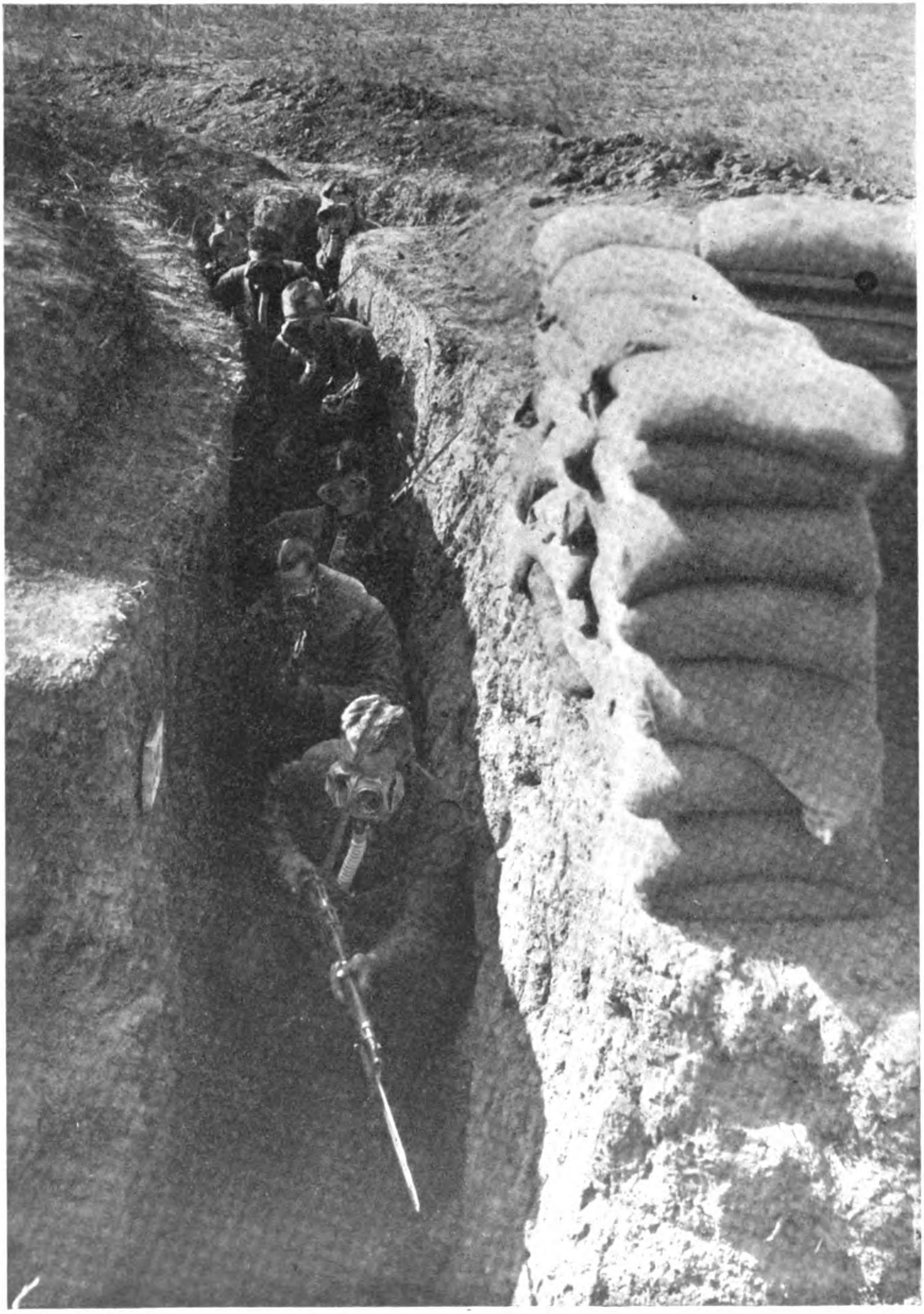

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*With a million and a half men under arms, the **United States** is **directing every energy** to prepare its new army for immediate service on the **western** front. **This photograph of a training camp shows** an **advance through trenches in the face of a gas attack, special interest** attaching to the new type of gas mask and the bends in the **trench** line to prevent **effective enfilade fire when attacked on the flanks***

THE WIRELESS AGE

WORLD WIDE WIRELESS

Remarkable Achievement in Italian Link with U. S.

THE announcement that Italy and the United States have recently been connected by wireless telegraphy deserves more notice than it has received. This achievement probably makes a back number of the great wireless station at Nauen, near Berlin, which has been so useful to Germany, and which, when the war broke out, claimed to be the most powerful in the world, with an effective range of between 5,000 and 6,000 miles. From the nearest point in Italy to the United States trans-Atlantic station at Arlington, near Washington, is not less than 6,200 miles, and to send an intelligible message across that distance might be more than even Nauen could accomplish. Owing to the hostility between the ether waves which carry wireless messages and sunshine, it is always easier to send messages long distances in northerly latitudes than in those more south, and the power required to cover a given distance increases with nearness to the equator. The wireless route between Rome and Arlington is for a good part of the way at least 800 miles nearer the equator than that between Nauen and the United States, which fact considerably adds to the achievement of the Italian and American experts.

American Marconi Company's Service in Year of War

THE annual report for 1917 of the Marconi Wireless Telegraph Company of America is the record of the adaptation of the corporation's resources to the nation's war needs. All the radio stations, including the high power stations in the United States, were immediately taken over by the government and used exclusively for government communication under the direction of the Navy Department.

In spite of this condition, the company reports an exceedingly successful year. According to John W. Griggs, president of the company, the net profits for the year, after utilizing $162,819.75 for reserves, amounted to $617,772.69 against $259,888.80 in 1916, or an increase of 138 per cent. This sum has been added to the surplus, increasing that amount to $1,419,549.01, and the reserves set aside for depreciation amount to $573,461.32 additional. The gross earnings from operations for 1917 were $1,229,467.55, compared with $796,290.39 for 1916.

In lining up its resources for the government, the Marconi Company faced these three major needs, according to the report:

"First—Facilities and trained experts for the manufacture of the new wireless equipment for the large number of vessels built and commandeered by the United States Shipping Board and the Navy Department.

"Second—A constant supply of capable, licensed wireless operators, for service on the rapidly increasing merchant marine.

"Third—Trained construction men to install wireless apparatus on the vessels, and engineers capable of coping with the many problems of wireless communication and production.

"To meet the first need, the company has built two large additions to its factory in Aldene, N. J., and is now engaged in building a third addition, which will soon be completed. This has resulted in more than trebling the capacity of its works, which are operating two shifts of mechanics a day, with a steadily increasing force of engineers, in the manufacture of wireless apparatus for government use.

"In order to meet the second and third needs, the company has increased its school facilities for the training of wireless operators, and is financing the training of a force of junior engineers to deal with the many problems of wireless communication and production."

Through the organization of the Pan-American Wireless Telegraph and Telephone Company, plans were laid for the erection of a chain of high power stations which will connect up the United States with Mexico, the West Indies, Central and South America for commercial wireless communication. Work will begin in the Argentine as soon as plans can be prepared.

A 5 per cent. dividend was declared by the Board of Directors at a meeting held April 9th, 1918, payable August 1st, 1918, to stockholders of record July 15th, 1918.

Enormous Benefits Seen in Pan-American Wireless Project

THE recent organization of the Pan-American Wireless Telegraph & Telephone Company, in New York, is the most practical step yet taken to develop and extend the trade and general relations of the countries of the Western Hemisphere. In order to convey an adequate idea of the importance and value of this enterprise, it is necessary to describe its objects and to indicate the advantages that will follow their attainment.

The main purpose of the Pan-American Wireless Telegraph & Telephone Company is to connect the United States with all the countries of South and Central America, and the West Indian Islands, by wireless telegraphy. It will begin with Argentina, where the arrangements with the Government have been concluded and its technical experts are arranging for suitable sites, so that the high power stations and their necessary equipment can be completed and ready for actual working service within the next twelve months.

Commencing with Argentina, the work will be taken up in Brazil, and then in Uraguay, Paraguay, Chile, Peru, Ecuador, Colombia, Bolivia, and Venezuela successively, and as rapidly as the necessary arrangements can be made. Also, Mexico, together with the Central American Republics and the principal West Indian islands, will be included in the system.

Wireless stations, more powerful and complete than any heretofore constructed, will be erected in each of the principal trade centres of the various countries, and will be able to carry on a twenty-four hour commercial telegraph service with New York. Messages intended for Europe will be sent either directly or through the transatlantic wireless service of the Marconi Wireless Telegraph Company of America, making connections with Great Britain, France, Spain, Italy, Russia and Scandinavia, and from the Pacific Coast—San Francisco, California—wireless connections will be made, through Hawaii, with Japan and the Orient.

In the United States, the system will connect with the landlines of the Western Union Telegraph Company—with over 25,000 of that Company's stations—in every state of the Union.

And all of this greatly improved service will be done with such a substantial reduction of rates that business men of the Americas will not only find themselves effecting a saving of their present cable expense, but will be enabled to

send much longer and more frequent messages, and make use of the telegraphy in fomenting and carrying on their business to an extent hitherto undreamed of.

The fulfillment of this comprehensive program will be greatly facilitated by the adoption of the latest inventions in wireless telegraphy, including the patents and improvements of the American and English Marconi Companies and the Danish Poulsen-Pedersen system. These developments ensure the highest efficiency in speed, economy and accuracy.

The new company is in a very strong financial position with abundant resources for the carrying out of its great undertaking. No stock is offered for sale.

The President, Edward J. Nally, who has devoted a lifetime to the development and advancement of the commercial telegraph, telephone and cable business, and who is well known as having held high executive positions with the foremost landline companies of the United States, is also vice president and general manager of the Marconi Wireless Telegraph Company of America, which is the chief wireless company of the new world, not only with respect to its trans-atlantic and trans-pacific commercial service, and its many ship and shore stations, but also in that it is the largest manufacturer of wireless apparatus and equipment in the United States.

The Chairman of the Board of Directors is the Honorable John W. Griggs, former Attorney General of the United States, and ex-Governor of the State of New Jersey. The other officers are: Vice-Presidents: Dr. Washington Dodge, and David Sarnoff; Secretary: C. J. Ross; Treasurer: John Bottomley.

In addition to the Honorable John W. Griggs, other members of the Board of Directors are: Mr. Nally, Messrs. James R. Scheffield, Edward W. Harden, David Sarnoff, Frank N. Waterman, Dr. Washington Dodge, George Pope and Nathan Vidaver.

The entire official and technical staff of the Pan-American Wireless Telegraph & Telephone Company, is made up of men who are thoroughly experienced and qualified for the practical working out of their plans, and they are, as well, men of vision and imagination, who have long been studying the question of how best to bring into closer harmony the ideas and ideals of North and South America. Their conclusion that the lack of a cheap and rapid system of telegraphic communication is the most important factor among the hindrances to such better international understanding, was authoritatively corroborated during the sessions of the Pan-American Financial Conference held in Washington in May, 1915. At that conference, which was attended by the President of the United States and members of his Cabinet, as well as by the most influential representatives of all Latin-American countries, there was hardly a speech or report of an individual or group which did not contain some reference to the urgent necessity for improved telegraphic service between the two Americas.

These reports not only express with high authority the true needs of the prevailing situation, but they also assure the hearty support and co-operation of all American Governments in the furtherance of the work undertaken by the new company. Every one of the points urged by the Conference is embraced in the plan proposed, including the offering of special rates and inducements to newspapers and press associations so that they will send and distribute reports and despatches of greater length and greater frequency than is possible under present conditions.

Another service, which has proved very popular in trans-atlantic and trans-pacific wireless business, will be the transmission of night and week-end letters at reduced rates.

Every one knows what wireless telegraphy and its great inventor, Marconi, have accomplished in the interests of humanity. In the conduct of the war now raging in Europe, it has been a potent factor in the field, in the air, and on the waters, and the improvements that have resulted from the forced stimulation

have brought the art forward by leaps and bounds. When the war is over and normal activities of the world are resumed, wireless telegraphy will take its place as one of the most important arts in the progress of humankind, and the organization of the Pan-American Wireless Telegraph & Telephone Company offering every moral and material guarantee for the fulfillment of its objects will be recognized as an epoch-making event.

It is earnestly to be hoped that not only the Governments but the business men, both individually and through their Chamber of Commerce and other organizations, in all the countries of Latin-America, will actively co-operate and offer their aid to the fullest extent possible, so that there may be no unnecessary obstacles placed in the way of the speedy consummation of this plan for an all-American system of wireless stations which, by linking the countries from Alaska to Cape Horn, will so materially advance the interests of every one concerned.

Improved Equipment for Nauen

THE German Government's wireless station at Nauen has been greatly improved since the outbreak of the war, according to the Frankfurter Zeitung. Instead of a single transmission tower 300 feet high it now has ten towers ranging in height from 360 to 890 feet, while the distance through which messages can be transmitted has been extended to 6,200 miles.

Brazil to Have New Link to Rubber Section

THE Brazilian Government has authorized the expenditure of a sum not to exceed 200,000 milreis (paper milreis = about 27 cents) for the erection and installation of a wireless telegraph station at Boa Vista do Rio Branco, State of Amazonas. The State of Amazonas, which has an area of 1,894,724 square kilometers and a population of 379,000 inhabitants, is the largest State in Brazil. Manaos, the capital of the State, where a Marconi station has been in operation for several years, is a thoroughly progressive city of more than 100,000 inhabitants, with fine public buildings and a theater which rivals in beauty of architecture, arrangement, decorations, and equipment the principal theaters of the world. This State is the center of the great rubber section of Brazil, and the city of Manaos, its capital, is nearly 1,000 miles from the mouth of the Amazon River.

Using Wireless to Measure Sea Distances

PROFESSOR J. JOLY, of Dublin, has suggested a method of measuring distances by wireless. He relies on the fact that disturbances travel with different speeds in different media. Sound travels eleven hundred feet or more a second in air and about forty-seven hundred feet a second in water, while wireless or light signals travel at equal speeds. Thus, if a shore station sends out these different signals at the same time, they will not be received by the ship simultaneously; there will be an interval of time between them that will increase as the distance of the ship from the shore increases. If a mile from the station, a ship would receive a sound signal in air 4.5 seconds later than a sound signal in water, and an air sound 5.5 seconds, or a sound in water 1.2 seconds, later than a wireless signal. Therefore, with a knowledge of the interval which elapses between the receptions of any two of these different signals, it is a comparatively simple matter to calculate the source from which they have been sent.

To Paris by Relay from New Station at Guadeloupe

IT is announced that the wireless station at Destrellan will soon go into operation. Its equipment is sufficiently powerful to permit of communication with the most remote of the West Indian islands and with all vessels coming from

Eur.pe, the United S... South America. It can also receive messages from the Eiffel Tower, b... not send messages through to Paris direct. However, by using the intermec... stations of Dakar and Bizerte, the Guadeloupe plant will probably be able to ..rward radiograms to Paris. The Destrellan station is owned by the colonial government, but, it is said, will be open to the public.

Unique Buzz of the Familiar Radio "Bug"

REMINISCENT of the days before the booming guns of war cut off wireless experimentation and its queer twists and claims of self-admitted inventors is the recent occurence in Reno, Nev., when a man who gave his name as James Dillon walked into the Mount Rose Hospital and in a matter of fact way requested that he be given an anaesthetic and killed. He stated that it was absolutely necessary that he died if the present complication of world affairs were to be properly adjusted.

Questioned as to his antecedents by the examining physicians Dillon stated that he wasn't born at all but "sprung up" in Montana and that he was raised by Indians until he was 15 years old, when he took up the study of wireless telegraphy and became the greatest wireless man in the world, not even excepting Marconi.

"I am able to send a wireless message to heaven or hell, and have 523 fairies in my employ who work in receiving stations at both places," he announced.

Dillon said that he was in Germany when the war broke out but that he left Europe because the big guns made such a noise that it completely disrupted his wireless system. Since then, according to his wanderings, he has traveled all over the world, trying to get in connection with his staff of sprites, but unsuccessfully.

Despairing of being able to conduct further research in the heavens or the nether regions and thinking that this was a punishment for some great sin he had committed, he said that he had determined to end his life in order that the bells might stop ringing in his head and that all might be well with the world.

He was thereupon ceremoniously interned in the state lunatic asylum.

A New Cuban Station in Isle of Pines

WORK has commenced on the new wireless telegraph station at Nueva Gerona, Isle of Pines. The building in which the installation will be made is about completed. This building is constructed of concrete blocks, villa style, with tile floors, two bed-rooms, a sitting room, kitchen, and bath and an office, estimated to cost $16,000. The station will be installed as soon as the building is ready. In addition to the building referred to, a tower 251 feet high will be erected at a cost of $13,000. It is intended to open the station to public use.

Navy Has No Room for Radio Women

WOMEN telegraphers who wish to render their country a patriotic service can best do so by accepting employment with a telegraph company, thereby releasing a man for military duty. This is the advice of naval authorities to women seeking to enlist as Navy radio operators. It is land-wire telegraphy, rather than radio, say the Navy authorities, that women should now study.

Women radio operators are not being enlisted in the Navy nor enrolled in the Naval Reserve Force for radio telegraphic duties, according to a statement made by the Naval Communication Service. At the outbreak of the war several women were enlisted as radio operators, but their employment in this capacity was found to be, generally speaking, impracticable. The Navy is supplying merchant ships as well as naval vessels, quarters on both being provided for men only.

Instructors in Navy Radio Schools must be radio electricians with actual shore and sea experience, hence women will not be accepted for this duty.

Six German Wireless Plants in Mexico

GERMANY is in direct daily touch with military developments in the United States. Her widespread espionage system in this country has an open road of communication to Berlin through no less than six powerful wireless stations in Mexico.

This is the statement of William W. Canada, for twenty-one years United States Consul at Vera Cruz. He has just returned from Mexico. He said:

"I have notified the State Department of these wireless stations. It is a matter of record at Washington. One of the stations is at Mexico City. We located another in the northern part of the State of Vera Cruz just before I left. It was built on the highest peak in the section. There are three or four others. Any one of them is powerful enough to transmit messages to Germany.

"Mexico is overrun with German agents. Many come from the United States, and others from South America, some by way of Honduras. German propaganda is being carried on in wholesale fashion. Several important newspapers have been subsidized. The German agents supply them with white paper, among other things. We have proof of this.

"Germany has a complete line of communication from Washington to Berlin by way of the wireless stations in Mexico. German agents are spending money lavishly in Mexico, and they are overlooking no opportunity to poison the minds of Mexicans against the United States. They are meeting with some success in their efforts."

California Naval Radio School Extended

THE United States government is planning the expenditure of $50,000 at the Chollas Heights wireless station, near San Diego, Calif., in order to make provision for a class of 100 or more wireless operators, who will be trained there permanently.

Gunner H. L. Rodman, U. S. N., who is located at the station, explained the future plans of the government, to make the Chollas station a great training school for wireless operators.

According to his statement, the government expects to spend about $50,000 at once in new equipment and in living quarters for the men.

The World Scope of Governmental Air Messages

WIRELESS words, which Gilson Garner characterizes the new war weapon, are interestingly dealt with in recent correspondence from him in Washington.

He asks that Americans think of the world as a great silent globe, the sky enclosing it, on which are creatures with a miraculous power to throw their voices across the ether. Think of these creatures talking to one another, interrupting one another, drowning out the talk of one another. There you have a mental picture of what is taking place daily and nightly in what might be termed the war of the wireless.

It is a war of words. It is literally a struggle of words carrying propaganda —all the official statements of all the world in regard to the war.

The wireless station at Arlington, Va., sends out messages which are taken at Nauen, near Berlin. The Nauen towers send out messages which are heard at Southampton, England; at the Eiffel Tower in Paris; at the Arlington station here, and in Cuba and in Mexico. They get to Russia. They are sent to the world in all languages—often from Germany in English, and from England in French, German and Russian.

The wireless has made the world literally a whispering gallery. The governments have taken the wireless for war purposes, and every wireless station is the mouthpiece of a government.

In the old days ambassadors carried carefully written state communications, messages and letters from one government to another, bearing seals and red tapes. These were the voices of one nation to another whether at war or at peace.

Today the ambassadorial function is gone. Nations, at war or at peace, cannot but hear one another's voices. They are in daily, nightly, and hourly communication with one another through the air.

Germany puts out peace feelers. Our state department complains at Germany's announced terms. But they come through the air and cannot be checked. Whatever the kaiser or the reichstag, or Von Hindenburg wants said is said through the air. Also whatever Lloyd George or Woodrow Wilson wants said.

Lately a long dispatch floated in from Berlin telling exactly where American troops are located on the French front; just how many there are; what their physical condition is; comments on their morale; statements about orders issued by Pershing against visiting Paris.

Also came from Berlin an account of the Bigelow kidnapping near Cincinnati, with the declaration that tar-and-feathering was becoming common in the United States.

Communications between nations which are official and secret go in code. Of course many of these codes are ultimately deciphered and information leaks, but the codes are changed almost daily.

The wireless has made international communication simple and absolute. There is no room any longer for misunderstanding by reason of failure to receive messages. If language can convey it the governments of the world can adjust their ideas one to the other.

Negroes for Army Signalmen

PLANS are under way for the forming of colored classes in wireless telegraphy to meet the demand being made on wireless operators by the War Department. To be eligible for admission the applicant must be registered under the draft act, but he cannot be enrolled if he has been called by his local board.

Through the activity of Emmett J. Scott, special assistant to Secretary Baker, the War Department realizing the expediency of the plan has authorized Adjutant-General H. P. McCain to issue orders for the organization of wireless telegraphy classes of colored registrants in Richmond, Virginia.

The orders issued by the Adjutant-General read as follows:

"The Federal Board of Vocational Education, which is handling the training of draft registrants as operators at Armstrong for the signal corps, has been notified that it is the desire of the chief signal officer to have a class started under the supervision of the Federal Board for High School, Richmond, with the view of furnishing operators for the Three Hundred and Twenty-fifth Field Signal Battalion (colored)."

*Dispatches from France telling of the excellent assistance rendered by Portugal's army in resisting the German drive, make this view of the cart wireless station of this minor Republic's field forces of **unusual interest**. The equipment shown is similar in type to the American cart stations and is said to be of great flexibility and power*

Radio Science

Weagant's Method for Group Frequency Tuning

EXPERIMENTS have shown that when the local circuit of a radio receiving system is fitted with a group frequency or audio frequency tuning circuit a diminution of the strength of signals results. A system has recently been disclosed by Roy A. Weagant, chief engineer of the American Marconi Company, wherein group frequency tuning is possible without the usual loss of signals. The connections are shown in figure 1. The primary and secondary

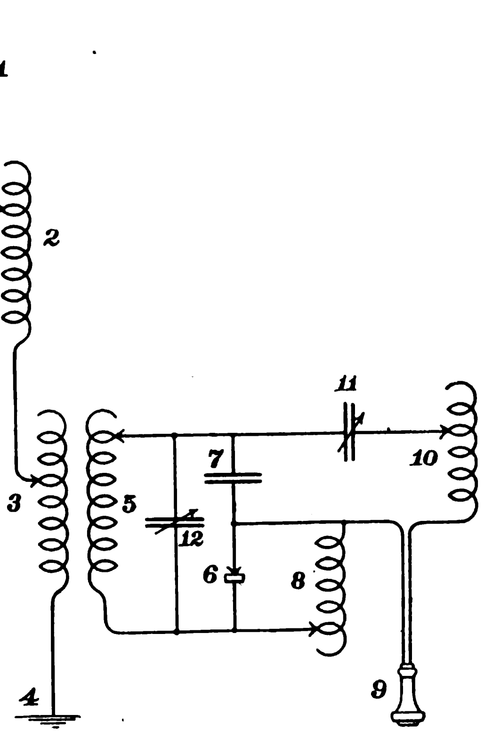


Figure 1—Weagant circuit for group frequency tuning

windings of the receiving tuner are indicated at 3 and 5, respectively, the shunt condenser at 12, a solid rectifier at 6, and a series condenser at 7. The group frequency tuning circuit includes condenser 7, a variable condenser 11, a variable inductance 10, and the head telephone 9.

Detector 6 is shunted by a coil 8, which has the effect of maintaining the signals in the telephone 9, at the strength which would be secured were the group frequency tuner removed. The principle of operation is somewhat

as follows: The detector 6, while permitting the passage of impulses in one direction, tends to prevent their passage in the other direction, and thus interferes with the oscillation of the circuit. By placing an impedance in shunt with the detector, however, a path is provided for the passage of oscillations in both directions, thus improving the operation of the circuit. The impedance 8, being of relatively high value, does not, however, interfere with the operation of the detector in the case of high frequencies. Mr. Weagant states that the best results are obtained when the inductances 8 and 10 are substantially of the same order, each of them being about 1,000 times the inductance of the secondary 5.

An Amplifying Receiving System

IT is a well known phenomenon that if a coil of wire without shunt capacity (external condenser) is excited by a transient E. M. F. it will oscillate at a frequency determined by the inductance and the distributed capacity between turns. If such a coil is earthed at one end, its period of oscillation will be decreased and a loop of potential will exist at its free end. This is well illustrated in the action of the Oudin resonator. An amplifying receiving system based to some extent upon this phenomenon has recently been devised by E. E. Bucher.

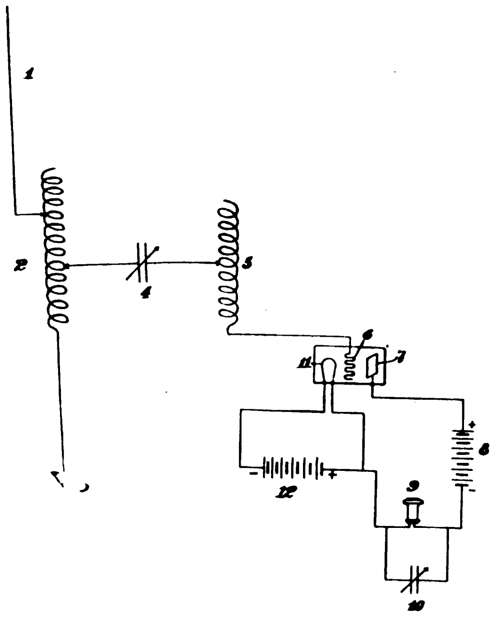


Figure 2—Amplifying receiving system devised by Bucher

Three practical circuits are shown in figures 2, 3, and 4. In figure 2 the antenna inductance is represented at 2, and the secondary inductance at 5, the coils being coupled together by the variable condenser 4. Coil 5 terminates in the grid element of a valve. The plate circuit of the valve includes the battery 8, the telephone 9, the shunt variable condenser 10, and the filament heating battery 12. Coil 5 is of such dimensions that the complete circuit, from the grid 6 through coil 5 through condenser 4 through coil 2 to the earth 3, has the same natural frequency as the incoming oscillations. During the reception of signals a very high E. M. F. exists at the free end of the coil 5,

which varies the electronic current flowing from the filament to plate. In other words, a circuit of this type impresses upon the grid a much higher E. M. F. for a given group of oscillations than would be obtained from the usual secondary circuit.

By shunting the plate circuit with inductance and capacity, this circuit is applicable for the reception of undamped oscillations, and will give strong signals.

A slight modification of this system is shown in figure 3, where the antenna inductances are shown at 2, and the circuits of the grid 6 of the vacuum valve leading from a contact point on the upper end of coil 2, through the inductance 5 to the condenser 4. Inductance 5 is shunted by a small variable condenser 13. It is found that by varying the capacity of condenser 13, the tuning of the receiving circuit becomes more sharply marked, aiding in the elimination of undesired signals. The use of this conductor is not recommended, however, under all conditions, as, for instance, in the reception of very long wave lengths a small capacity has a certain utility.

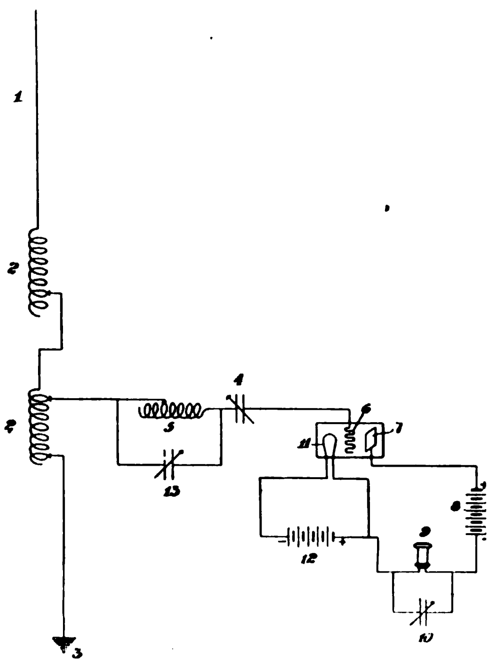


Figure 3—Receiving circuit to eliminate undesired signals

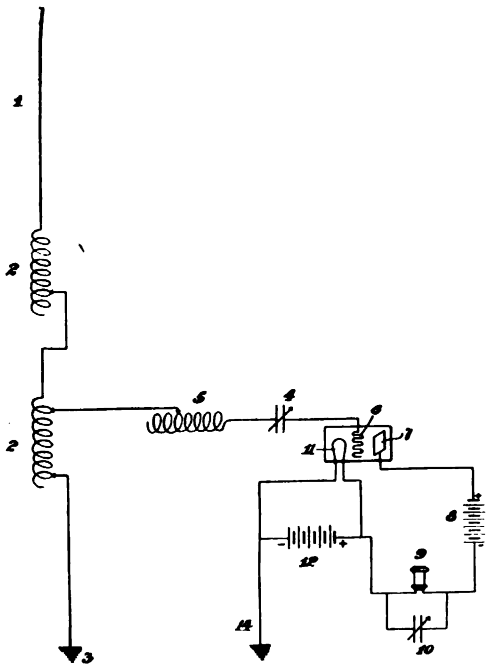


Figure 4—Receiving system with open circuit oscillator

A further modification is shown in figure 4, where the circuit including the coil 2, coil 5, series condenser 4, and the grid 6 is adjusted to the frequency of the incoming oscillations. In this circuit the valve is grounded at 14, but this does not affect the radio frequency tuning of the circuit. It, however, eliminates certain local disturbances, such as electrostatic induction from nearby alternating current power circuits. But as far as the tuning of the radio frequency circuits is concerned, removing the earth connection will have no effect whatever.

It has been reported that by means of this open circuit oscillator several oscillation detectors have been connected to the same antenna circuit, each

tuned to a different frequency of oscillation. The detectors functioned without interference.

Mr. Bucher states that by the term "open circuit" is meant a circuit which oscillates as an open circuit or linear oscillator after the manner of the Oudin coil, and which is of such high inductance and low distributed capacity as to cause a great rise of voltage at the end terminating in the detector. In this sense, such a circuit remains operatively an open circuit even if the filament of the valve detector connected thereto is grounded. In other words, it is a circuit in which a great rise of potential occurs, but no current flows in a closed path; rather, there is merely the surging of the charging current incident to the rise of the oscillating voltage at the end terminating in the detector.

Constant Pressure Solid Rectifier

THE imperfections of spring contacts used with rectifying elements have been generally recognized. It has been difficult to obtain with the best spring arrangement the correct pressure for maximum strength of signals, and if, after a given transmitting period, the operator is required to immediately adjust his receiving apparatus to sensitiveness the chances are one in ten that he will be able to find the required adjustment in the brief period at hand before the reply is received from the distant transmitting station.

A recently devised detector holder in which the pressure of the rectifying element is secured by a balance device, instead of a spring, is shown in figure 5. In this drawing, balance lever L has secured to it a brass pin, over which is slipped a brass holder to take the brass contact-point. Contact 7 rests upon a rectifying element such as carborundum silicon, molybdenite or bornite. The crystal is held in the containing cup C, the cup being fastened

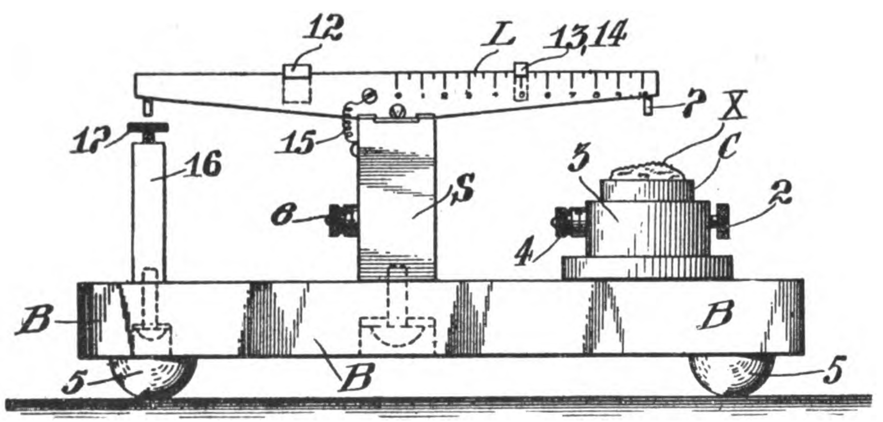


Figure 5—A detector holder with balance device

rigidly by the thumb screw 2. The base B is provided with soft rubber feet 5 to eliminate mechanical shock.

In order that the device may be operated with various samples of each of various rectifying solids, say for purposes of measurement, an adjustment is provided consisting of varying weights 13, 14, operating on lever L along the graduated scale which extends from the knife-edge support to the center of pin 7. Weights 13 and 14 may be of one gram of aluminum and 10 grams of brass, respectively.

A conducting lead 15, figure 5, connects L and S in shunt to the knife-edge support to insure good circuit connections. This lead should be of fine copper wire in order to have a minimum of resistance.

If a device of this kind is intended to be used exclusively in a commercial way, by operators, it is recommended that no weight adjustment be permitted, provided that the operators are furnished with cups C containing a given solid rectifier of constant sensitiveness. The device should then be set to the pressure determined in the laboratory by a control instrument so that the optimum sensitiveness for a standard material can be readily obtained.

The great advantage of this holder, according to the inventor, is that there is practically no adjustment to the device. It is always ready for use provided the contact point 7 has the proper predetermined pressure. In the event that the operator's testing buzzer shows that the device has for some reason become inoperative, as to the particular surface point of crystal X in contact with P, it is permissible for him to move holder 3 slightly to obtain a new surface contact. This, however, will seldom be required if the rectifying material is properly selected. But should inoperativeness occur, as it may in the midst of a message, when it is essential for the operator to be able to restore the detector to sensibility, instant restoration is possible with this apparatus, for the contact pressure is automatically maintained constant, irrespective of the movements of holder 3 and of the consequent varying elevations of X, thereby caused to engage with contact point P.

Novelty in the Construction of Quenched-Spark Gap

WHETHER or not the quenched-spark discharger which George Seibt has recently devised is commercially practical is an open question.

Gaps of this type heretofore consisted of a number of copper plates separated by insulating gaskets; these were mounted in a frame and tightly

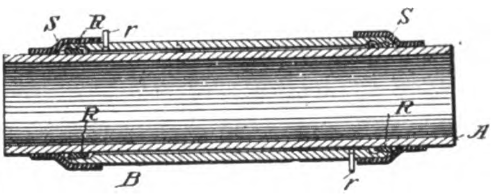


Figure 6—Section of quenched spark gap

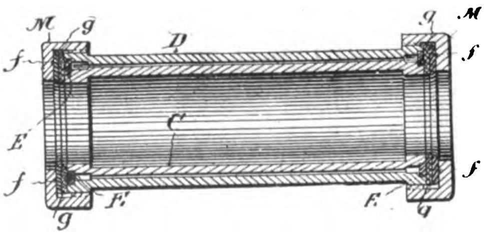


Figure 7—Modified construction of spark gap

clamped together, but Seibt declares that they were difficult to cool. Moreover, their construction did not permit the admission of the gas to the discharge surfaces which has been found to effect a marked increase in efficiency.

In Seibt's quenched-gap, shown in figures 6, 7, and 8, the spark occurs between two concentric cylinders, with an air space of the requisite separation, say 1/100 of an inch.

In figure 6, the gap element comprises the inner tube or electrode member A, and the outer tube or electrode member B, the former being mounted concentrically within the latter with both ends extending beyond the ends of the outer section B. The exterior diameter of the inner section is slightly less than the interior of the outer section, so that when they are assembled concentrically or with their geometric axes coinciding, a spark gap space of uniform thickness is formed. These sections may, of course, be maintained in axially centered relation in any convenient manner. Packing rings R interposed between the sections at their ends have been found to form a suitable insulating material.

It is important that provision be made to exclude air from the spark gap space between the sections. This obviously may be accomplished in several different ways. The packing R may be made to serve the purpose, but the inventor has shown other means. For example, if it is desired to fill the spark gap space between the sections A and B with a suitable gas, a short pipe section r, may be tapped or otherwise inserted through a transverse hole formed through one of the sections, as B. This pipe delivers into the space between the sections. Gas may thus be supplied to the spark gap space and when it is sufficiently filled, the section r may be closed up.

In figure 7, a slightly modified construction of the spark gap is shown. In this figure the inner and outer sections C, D, are substantially of equal length, and are held assembled concentrically by means of cap rings or nuts M, applied over the ends. The sections C, D, are separated or spaced apart from

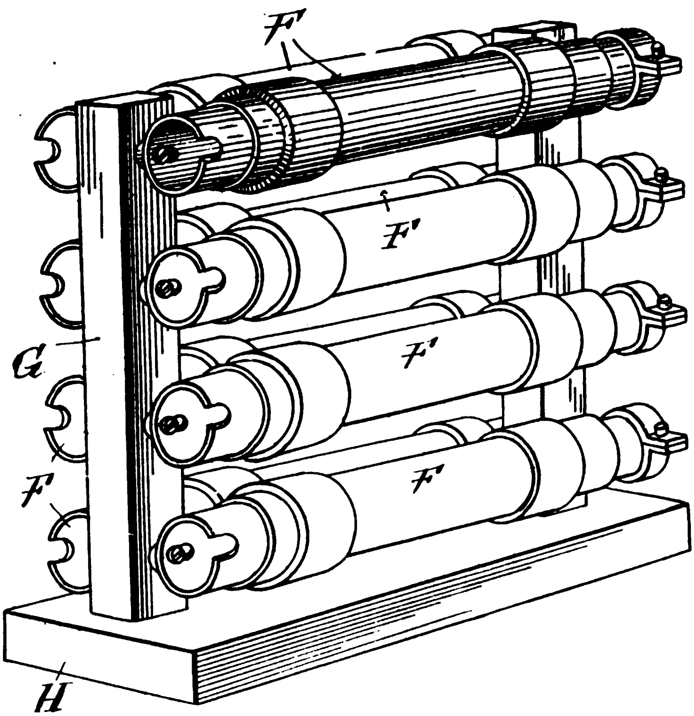


Figure 8—Complete spark gap with units assembled

each other and held in coaxial relation by means of the separating rings E, at their ends. Packing rings or disks g, of rubber or other suitable material, serve to exclude air from the space between the sections, while the caps or nuts M, are insulated from the inner section C, by means of the insulation indicated at f.

The complete spark gap is shown in figure 8, where a number of units are indicated at F. When assembled they may be held or supported preferably in parallel relation by the supporting standards G, on the base H.

By employing tubular sections for the units, and then setting these into a vertical position, a chimney or smoke-stack effect is produced. That is, the heat developed creates a natural draft of air through the bore of the inner tube, thereby absorbing and carrying off the heat. This cooling may be increased, of course, by artificially maintaining a draft of air through the bore of the inner tube.

(C) Press Ill. Svce.

The close relationship between Italy and the United States, further fostered by the new wireless link across the Atlantic, has acquainted Americans with the amazing resourcefulness of this nation and its remarkable army. The howitzer shown in the picture is one set down in a public square of a village on the Piave, a powerful weapon of great range, whose firing is directed by wireless from observation stations nearby

THE DYNATRON

A Vacuum Tube Possessing Negative Electric Resistance*

By ALBERT W. HULL, Ph.D.

(Research Laboratory, General Electric Company, Schenectady, New York)

1. Definition

The dynatron belongs to the kenotron family of high vacuum, hot cathode devices which the Research Laboratory has developed. Two members of this family, the kenotron rectifier and the pliotron, have already been described.[1] The fundamental characteristic of kenotrons is that their operation does not depend in any way upon the presence of gas.

In construction, the dynatron resembles the kenotron rectifier and the pliotron. In principle and operation, however, the three are fundamentally different. Each utilizes a single important principle of vacuum conduction. The kenotron rectifier utilizes the uni-directional property of the current between a hot and cold electrode in vacuum. The pliotron utilizes the space charge property of this current, which allows the current to be controlled by the electrostatic effect of a grid. The dynatron utilizes the secondary emission of electrons by a plate upon which the primary electrons fall. It is, as its name indicates, a generator of electric power, and feeds energy into any circuit to which it is connected. It is like a series generator, in that its voltage is proportional to the current through it, but it is entirely free from the hysteresis and lag that are inherent in generators and in all devices which depend upon gaseous ionization.

2. Construction

The dynatron consists essentially of an evacuated tube containing a filament, a perforated anode and a third electrode, called the plate. The essential con-

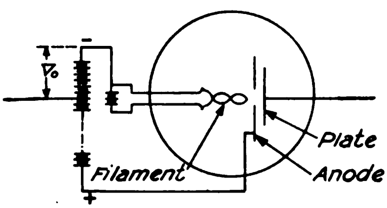


Figure 1

struction is shown in Figure 1. The plate must be situated near the anode, in such a position that some of the electrons, set in motion by the anode voltage, will fall upon it. A battery is provided for maintaining the filament at incandescence and for maintaining the anode at a constant positive voltage of 100 volts or more, with respect to the filament. This voltage is not varied during operation, and the anode plays no part in the operation of the tube except to set in motion a stream of primary electrons, and to carry away the secondary electrons from the plate; that is, to supply the power.

* Reprinted by permission from the Proceedings of the Institute of Radio Engineers.
[1] "Proc. I. R. E.," September, 1915.

Figure 2 shows the construction of one of the practical types of dynatron that have been developed. The plate has been bent into the form of a cylinder (Figure 2, a) in order to utilize more fully the electron emission from the filament, and the anode has been provided with a large number of holes, instead of one. This is accomplished by using a perforated cylinder (Figure 2, b), or spiral of stout wire (Figure 2, c), or a network of fine tungsten wires (Figure 2, d). The filament is a spiral of tungsten wire (Figure 2, e). The filament may be further provided with a heavy insulated wire along its axis (Figure 2, f), or surrounded by an insulated spiral grid (Figure 2, g), making a "four member" tube, which is called a *pliodynatron*. The characteristics of the pliodynatron are discussed in Section 8.

3. Characteristics—Negative Resistance

Electrons from the filament F (Figure 1) are set in motion by the electric field between F and the anode A. Some of them go through the holes in the anode and fall upon the plate P. If P is at a low potential with respect to the filament, these electrons will enter the plate and form a current of negative elec-

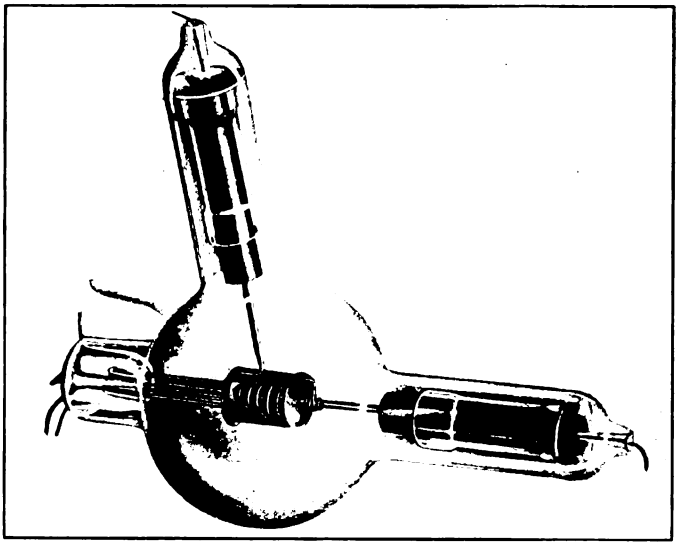


Figure 2—The dynatron

tricity in the external circuit. If the potential of P is raised, the velocity with which the electrons strike it will increase, and when this velocity becomes great enough they will, by their impact, cause the emission of secondary electrons from the plate. These secondary electrons will be attracted to the more positive anode A. The net current of electrons, received by the plate, is the difference between the number of primary electrons that strike and enter it and the number of secondary electrons which leave it. The number of primary electrons depends on the temperature of the filament and is practically independent of the voltage of the plate. The number of secondary electrons, however, increases rapidly with the voltage difference between plate and filament, and may become very much larger than the number of primary electrons; that is, each primary electron may produce several secondary electrons, as many as twenty in some cases.

The result is the characteristic voltage current relation shown in Figure 3. The abscissas represent voltages of the plate with respect to the negative end of the filament. The ordinates represent current in the plate circuit, reckoned positive for electrons passing from filament to plate, i. e., in the direction that is equivalent to positive electricity flowing from high potential to low across the vacuum. It is seen that for low voltages, the current is very small, since only those electrons which come from the most negative end of the filament are able to reach the plate. As the voltage is increased, the current increases rapidly, and at about 25 volts, the plate is receiving the full primary current from the whole filament. For all higher voltages, this primary current remains essentially constant. When the voltage is raised above 25 volts, however, the second factor becomes important. The primary electrons strike the plate with sufficient energy to cause the emission of secondary electrons, and this emission increases rapidly with the voltage, hence the *net* current to plate decreases rapidly. At 100 volts

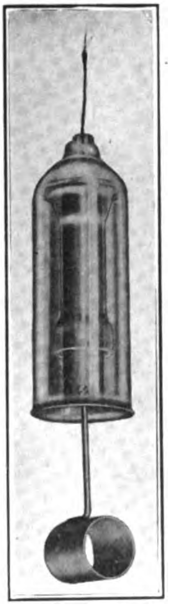


Figure 2, a

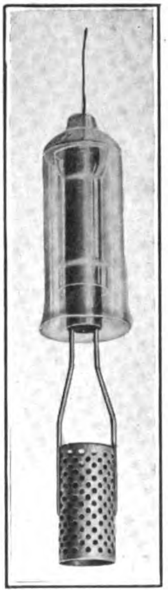


Figure 2, b

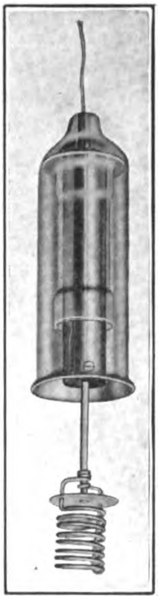


Figure 2, c

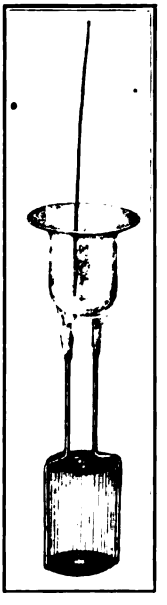


Figure 2, d

the number of secondary electrons leaving the plate is equal to the number of primary electrons entering it, so that the net current received by the plate is zero. As the voltage further increases, the number of secondary electrons becomes greater than the number of primary electrons, and the plate suffers a net loss of electrons; that is, the current is in the opposite direction to the impressed voltage. When the voltage is still further increased, a point is reached at which the anode is no longer sufficiently positive to carry away all the secondary electrons from the plate, and the current to the plate again becomes zero, and then rapidly rises to a value corresponding to the number of primary electrons.

It is evident from Figure 3 that over the range *A* to *C*, that is, between 50 and 150 volts in the case here represented, the current in the dynatron decreases almost linearly with increase of voltage, and obeys the equation $i = \frac{E}{\bar{r}} + i_0$, where i_0 and $\bar{r}$ are constants, $\bar{r}$ being negative. Since the constant i_0 does not affect the variable part of the current in any of the applications for which the

dynatron has been used, it is convenient to characterize the dynatron by the constant $\bar{r}$, which will be called its ***negative resistance***. The justification for this name is that the behavior of the dynatron in any circuit containing resistance, capacity, inductance and electromotive force can be accurately calculated by treating the dynatron as a linear conductor with negative resistance $\bar{r}$. Examples of such calculations are given below.

The term i_0 in the above equation disappears if the dynatron is connected in

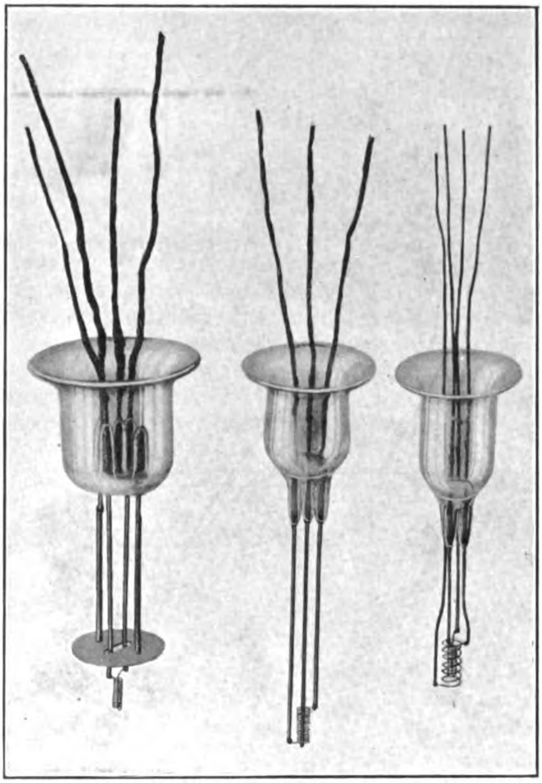


Figure 2, e *Figure 2, f* *Figure 2, g*

series with a battery, of voltage equal to that at which the dynatron current is zero (point B, Figure 3). The combination is a *true* negative resistance, for which $i = \dfrac{E}{\bar{r}}$. For example, if the dynatron of Figure 1 be put, with its batteries, in a box, and two wires be brought out through the box as terminals, one from the plate P and one from a point V_0 of the battery corresponding to the point B of Figure 3, this "negative resistance box" would behave in all respects like a conductor with negative resistance, over the range of voltage, positive and negative, represented by BC_0 and BA_0 in Figure 3.

The magnitude of the negative resistance, which is the slope of the current voltage curve, Figure 3, and the range of voltage $A_0 - C_0$ over which it can be used, depends upon the anode voltage, the temperature of the filament, and, to some extent, on the shape and material of the electrodes. The effect of varying

anode voltage alone is shown for two different types of tube in Figures 4 and 5, and the effect of varying filament temperature in Figure 6. It is seen that the effect of varying anode voltage is, in general, to shorten or lengthen the range of the negative resistance part of the curve, without changing the value of the

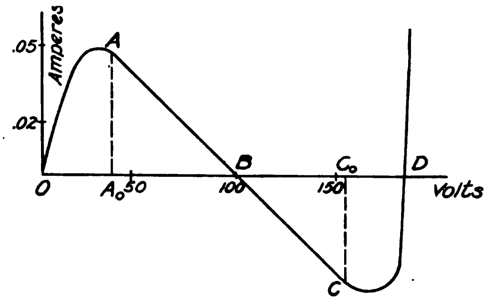


Figure 3

negative resistance. A slight shift in the voltage V_0 at which the curves cross the axis is, for one tube, to the right with increasing voltage, and for the other, to the left. It is therefore to be anticipated that with proper construction, this shift could be made accurately zero, and the operation of the tube be independent of the value of anode voltage over a wide range. Varying the filament temperature, on the other hand, changes the negative resistance only, without affecting the range or the value of V_0. This affords a simple means of adjusting the negative resistance to any desired value, but at the same time imposes a condition upon

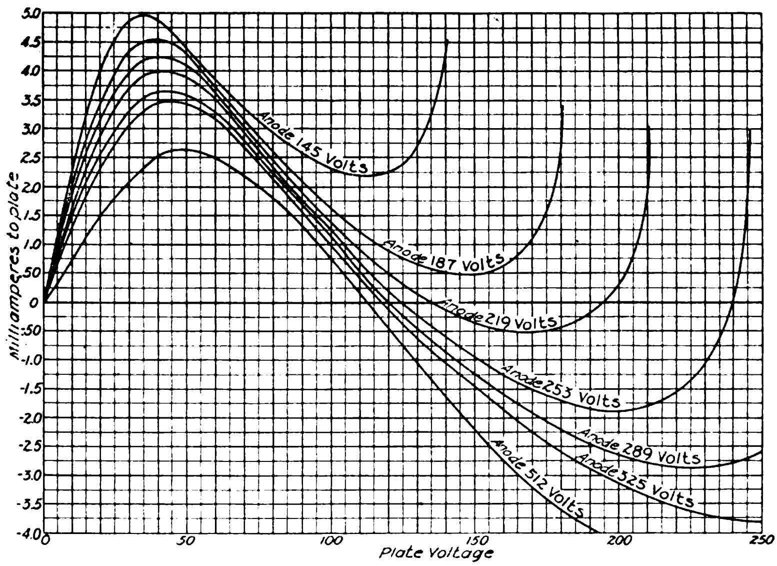


Figure 4

the uniform operation of the tube, namely, that the temperature of the filament be kept constant.

It will be noticed that the negative slope of the curves in Figure 4 is less straight than those of Figure 5. This is a disadvantage where exact balancing of positive and negative resistance is desired, but for some of the purposes of radio work to be described later, it is an advantage. The degree of curvature depends upon the construction of the tube, and may be made anything that is desired.

4. Dynatron in Circuit Containing Positive Resistance A. Series Connection. Circuit with Zero Resistance

If the dynatron is connected in series with a circuit containing positive resistance, the total resistance of the circuit is the algebraic sum of the positive and

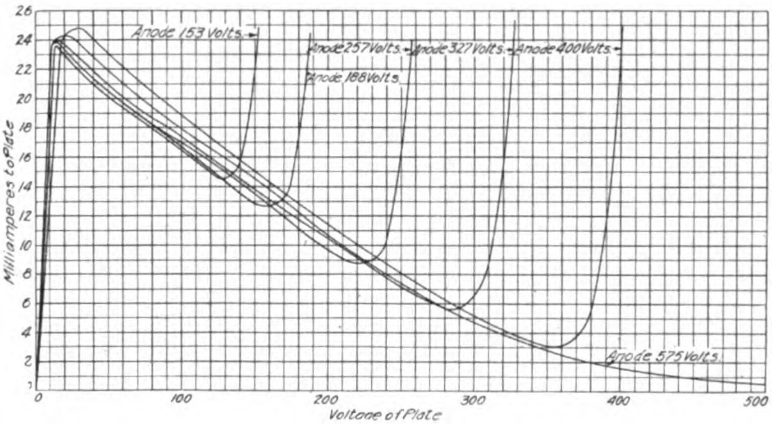


Figure 5

negative resistances, and may be made as small as desired by making the positive and negative resistances nearly equal. Such a circuit has very interesting properties. For, while the total resistance of the circuit is very small, that of its parts,

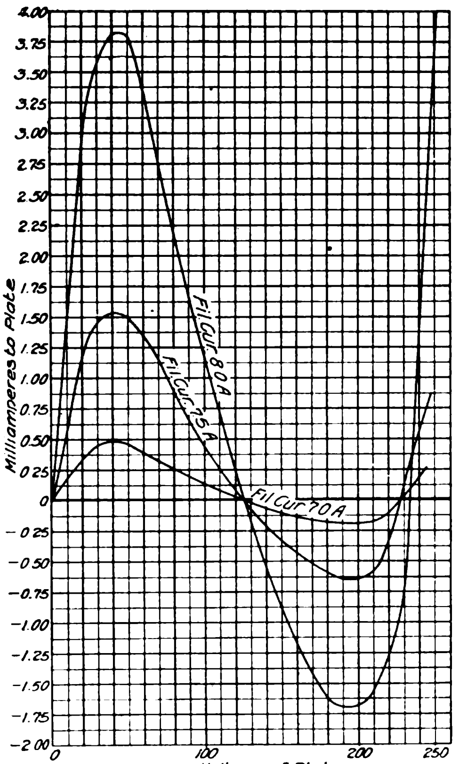


Figure 6

individually, is not. Hence a small change in the e.m.f. applied to the whole circuit will cause a comparatively large change in current, and therefore in the iR drop across each part separately; i. e., the circuit acts as a voltage amplifier.

(*To be continued*)

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

CHAPTER VI.

The Sailings

IN reference to a ship's position at sea relative to any other position, either one that has been left or one which the vessel is bound to, or the difference between any two positions, five terms are involved: The course or direction, the distance, the difference in latitude, the departure and the difference of longitude. The solutions of the various problems in which the mutual relations of the above terms are involved are called *Sailings* and are as follows:

Plane Sailing. In which we consider the earth as a perfectly flat surface or plane. In this sailing we can only consider the course, the distance, difference of latitude and departure. If two or more courses are involved, these are combined and the method is called *Traverse Sailing.*

Spherical Sailing. Whenever difference of longitude is involved the earth must be considered in its spherical form and therefore these sailings are called spherical sailings and include Parallel Sailing, Middle Latitude Sailing, Mercator Sailing and Great Circle Sailing.

Plane Sailing

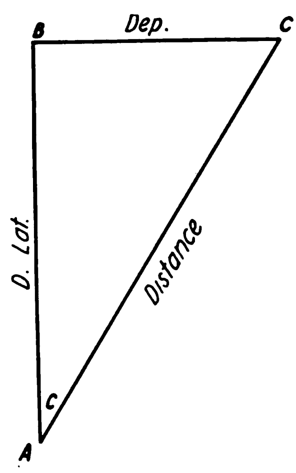


Figure 1

As said before, in plane sailing we take no consideration of the curvature of the earth but the problems are solved by considering the sides and angles of a plane triangle. Let in the triangle, figure 1, the angle BAC or C represent the course or rhumb line, the side AB the Difference of Latitude (D. Lat.), BC the Departure (Dep.), and AC the Distance from A to C. We have thus:

$$\text{Sin C} = \frac{\text{Dep.}}{\text{Dist.}}$$

$$\text{Cos C} = \frac{\text{D. Lat.}}{\text{Dist.}}$$

$$\text{Tang C} = \frac{\text{Dep.}}{\text{D. Lat.}}$$

From the above equations the following formulæ are derived and cover all the plane sailing problems:

Given	*Required*	*Formulas*	
Course and Distance	Diff. of Lat.	D. Lat. = Dist. cos C.	log & Lat. = log Dist. log + Cos C.
	Departure	Dep. = Dist. sin C.	log Dep. = log Dist. log + sin C.
Diff. Lat. and Departure	Course	$\text{Tang C} = \frac{\text{Dep.}}{\text{D. Lat.}}$	log Tang C = log Dep. — log Diff. Lat.
	Distance	$\text{Dist.} = \frac{\text{Dep.}}{\text{Sin C}}$	log Dist. = log Dep. — log sin C.
Course and Diff. of Lat.	Distance	$\text{Dist.} = \frac{\text{D. Lat.}}{\text{Cos C}}$	log Dist. = log D. Lat. — log Cos C.
	Departure	Dep. = D. Lat. tang C.	log Dep. = log D. Lat. + log Tang C.
Course and Departure	Distance	$\text{Dist.} = \frac{\text{Dep.}}{\text{Sin C}}$	log Dist. = log Dep. — log sin C.
	Diff. of Lat.	$\text{D. Lat.} = \frac{\text{Dep.}}{\text{tang C}}$	log D. Lat. = log Dep. — log tang C.
Dist. and Diff. Lat.	Course	$\text{Cos C} = \frac{\text{D. Lat.}}{\text{Dist.}}$	log cos C = log D. Lat. — log Dist.
	Departure	Dep. = Dist. sin C.	log Dep. = log Dist. + log sin C.
Distance and Departure	Course	$\text{Sin C} = \frac{\text{Dep.}}{\text{Dist.}}$	log sin C. = log Dep. — log Dist.
	Diff. of Lat.	D. Lat. = Dist. Cos C.	log D. Lat = log Dist. + log cos C.

In the above table we have included all the various problems which may be solved by plane sailing but the two first mentioned are most frequently used.

The problems may be solved either by plane trigonometry, by construction or by the use of the Traverse Tables No. 1 and No. 2 Bowditch. The latter method is by far the most convenient and will therefore only be considered in this series. Table No. 1 contains the Difference of Latitude and Departure corresponding to distances not exceeding 300 miles and to courses for every quarter point of the compass. Table 2 is of the same nature with this difference that the Difference of Latitude and Departure corresponds to every full degree of the compass and the distances extend to 600 miles.

Example. A ship sails NW by W ¼ W true a distance of 120 miles.

Required the Difference of Latitude and Departure made good.

Enter table 1 with the course 5¼ points taken from the bottom of the page and refer the distance 120 miles to the distance column. Opposite 120 you find the Diff. of Lat. to be 56.6 miles and the Departure 105.8 miles.

Note. If you take the course from the bottom you must also read the names Lat. and Dep. from the bottom of the pages.

Traverse Sailing

When the ship sails on various courses the ship's track will be irregular or zig-zag. This is called *Traverse,* and the method of *Traverse Sailing* consists of finding the difference of latitude and departure corresponding to the several courses and distances and combining them so as to reduce them to the equivalent of one single course and distance. This is done by determining the distance to North or South and to East or West made good on each course; then adding all the Northings also all the Southings; subtracting the lesser from the greater and calling the remainder Diff. of Lat. made good. Then add together all the Eastings and all the Westings; again subtract the lesser from the greater and call the remainder Departure made good.

Example. A ship sails the following true courses and distances: S by E ¼ E, 25 miles; E ¾ S, 50 miles; SW by W, 75 miles; W ¼ N, 100 miles; NW ¾ W, 125 miles.

Required Latitude and Departure made good; also course and distance made good.

SOLUTION

True Course	Distance	Diff. Lat N	Diff. Lat S	Departure E	Departure W
S by E ¼ E	25		24.3	6.1	
E ¾ S	50		7.3	49.5	
SW by W	75		41.7		62.4
W ¼ N	100	4.9			99.9
NW ¾ W	125	74.5			100.4
		79.4 N	73.3		262.7 W
		73.3 S			55.6 E
		6.1 N			207.1 W

Course Made Good......N 88° W

Distance Made Good......207 miles

To find the course and distance made good: Look in Table 2 for the difference of latitude in a latitude column and turn the pages over until you find the amount of departure to agree as near as possible. The exact amount is seldom found. If the *Diff. of Lat.* is greater than the *Departure* the course will be found at top of page, but if less than Departure it will be found at the bottom of page and the distance in the column immediately to the left hand side.

Parallel Sailing

In the foregoing the earth has been considered as a plane surface and its spherical form has not been taken into consideration. The Longitude or Difference of Longitude has therefore not been possible to consider.

Parallel sailing is the simplest form of spherical sailings. It is the method of converting the Departure into Diff. of Long. or the reverse; used when the ship sails on a due east or west course, or when the direction between two places is direct East or West.

In the figure No. 2, let A and B represent two places of the same latitude, P the adjacent Pole, AB the arc of the parallel of latitude through the two places; DE the corresponding arc on the equator intercepted between the meridian PD and PE; AB is the departure on the parallel whose latitude is BFE = CBF, and whose radius is CB.

Let Diff. of Long. represent the arc of the equator DE, which is the measure of DPE, the difference of longitude of the meridians PD and PE; R the equatorial radius of the earth, FE and FD; r the radius CB of the parallel AB; and L, the latitude of that Parallel.

Then, since AB and DE are similar arcs of two circles, and are therefore proportional to the radius of the circle s, we have:

$$\frac{AB}{DE} = \frac{CB}{EF}; \text{ or } \frac{\text{Dep.}}{\text{Diff. Long.}} = \frac{r}{R}$$

From the triangle FCB, $r = R \cos L$; hence

$$\frac{\text{Dep.}}{\text{Diff. Long.}} = \frac{R \cos L}{R}; \text{ or Diff. Long.} = \text{Dep.} \sec L;$$

$$\text{or Dep.} = \text{Diff. Long.} \cos L.$$

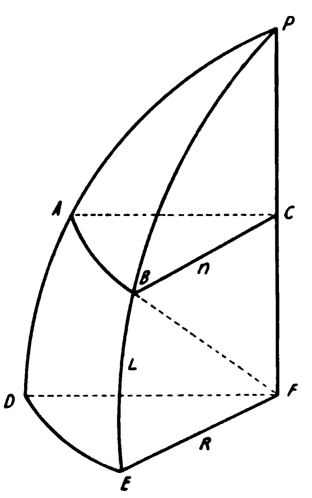


Figure 2

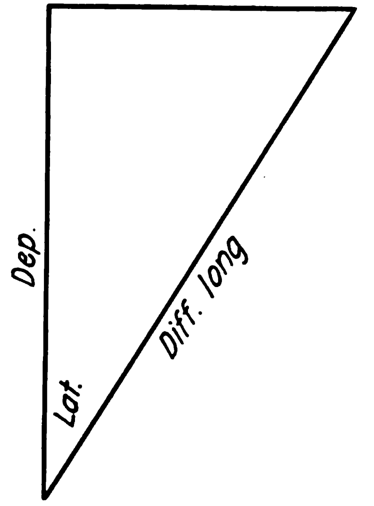


Figure 3

The above expresses the relations between *minutes* of Longitude and *miles* of departure.

Parallel sailing involves two cases: First where the difference of longitude between two places on the same parallel is given, to find the departure, and second where the departure is given to find the difference of longitude.

The solutions may be found by computation using logarithms, but the Traverse Tables are used to greater advantage as they are more convenient.

The tables are based upon the following formulæ:

D. Lat. = Dist. cos C, and Dist. = D. Lat. sec C, we may substitute for the column marked *Lat.* in Table 2 the *Departure,* for that marked *Dist.* the *Difference* of *Longitude* and for the courses at top or bottom of the page, the Latitude. Figure 3.

The tables then become convenient for making the required conversions.

Short Rule, for finding Diff. Long. when the departure is given. Enter table 2 with the Lat. as a course, select the amount of departure from a Lat. column; find the Diff. of Long. corresponding thereto in a Dist. column.

For finding the departure, when Diff. Long. is given, enter Table 2 as before, take the amount of minutes of longitude into a *Dist. column;* find the Departure in a *Lat. column.*

Example. A ship in latitude 40° 50′ North sails west 350 miles. Required the Diff. of Longitude.

Solution: Enter Table 2 with 41° (this being the nearest full degree) look for 350 in a Lat. column (you will find 350-2, this being the nearest) in the corresponding dist. column will be found 464; this is your minutes of Diff. Long. and = 7° 44′.

Example. A ship sailing on the parallel of Latitude 36° has changed her longitude 5° 10′. How many miles has she sailed?

Solution: 5 × 60 = 300′ + 10′ = 310, this being the Diff. of Longitude in minutes. Turning to 36° in Table 2 we find against 310 in the Dist. column; 250.8 in the Lat. column, this is the Departure or miles the ship has sailed in order to change her Long. 5° 10′.

Note. With miles in these articles, unless otherwise stated, we mean *nautical miles* or knots which have the same length as a minute of latitude or 6080 feet.

(*To be continued*)

New Navigation Plotting Chart

Invented by Capt. F. E. Uttmark

Marc St. Hilaire Method of finding a ship's position at sea is extensively used in the U. S. Navy and gaining in popularity in the Merchant Marine. It is one of the best ways of finding the ship's position by employing the intersection of the Sumner lines.

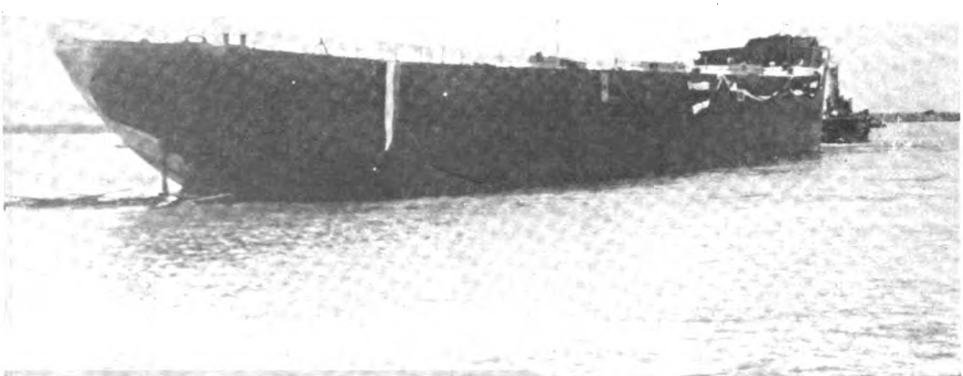
At night, dawn or twilight when the stars and planets, or the moon is visible and the horizon clear, we can always select two conveniently situated heavenly bodies from which observations may be taken and position plotted on the chart, thus enabling us to fix the ship's position at any desired moment. In day time we have often the sun and the moon visible at the same time, and occasionally the planet Venus is in such a position that we can observe it when it crosses the meridian and the sun is in the Eastern or Western sky, thus obtaining Latitude by the Meridian Observation and the ship's position by intersection of the Sumner lines. When the Sun alone is visible we need two observations with an interval of time.

The point of intersection of two Sumner lines may be found by computation or by plotting the lines on the chart; the latter method is by far the more simple.

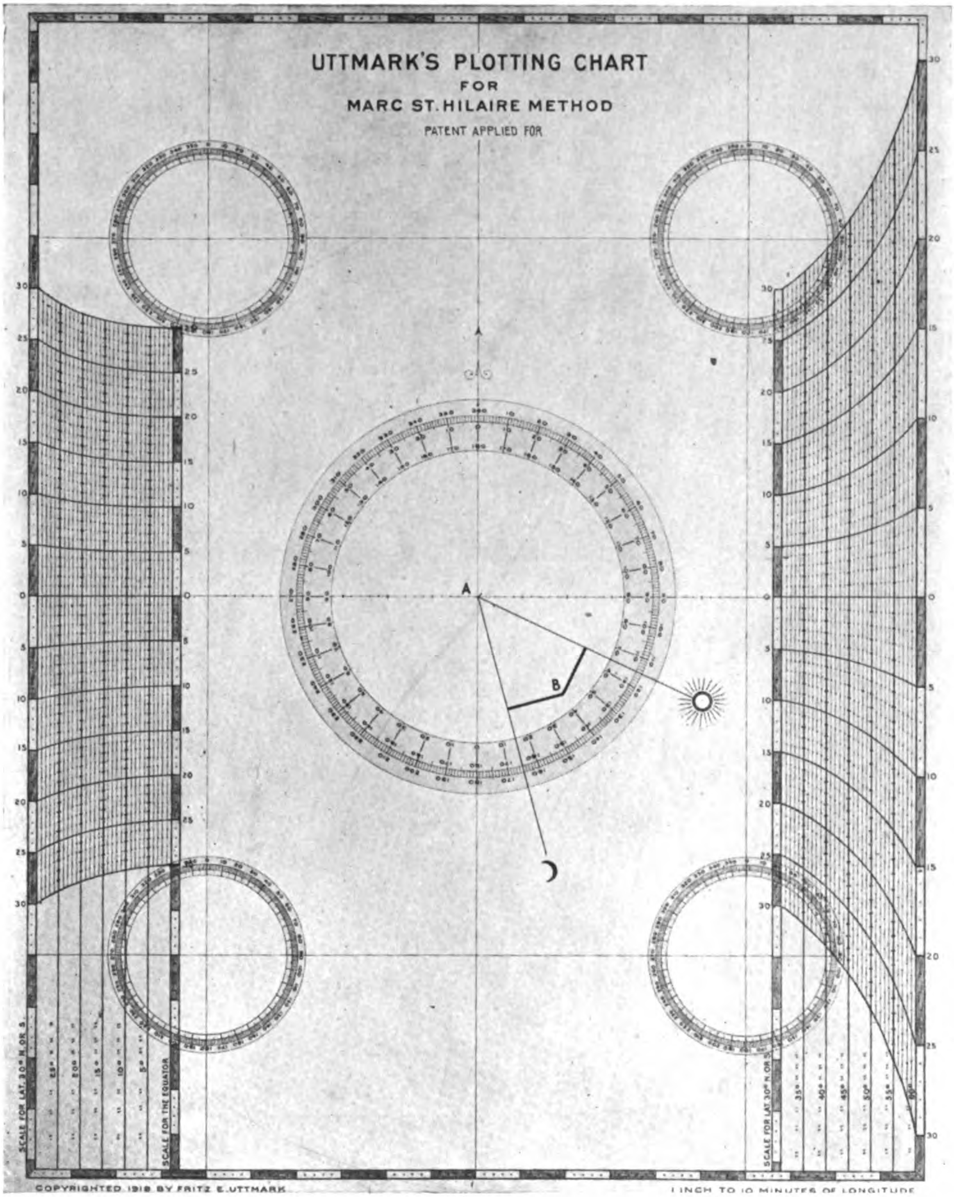
We have had specially designed charts for plotting purposes but the drawback has been the inconvenience of their bulk. To cover the latitude from the Equator to 60° a set of twelve charts (scale 4 inches to one degree of longitude) which is about the smallest scale that can be used for accurate results has been in use for many years, and contains over 200 square feet of paper.

This trouble is now over and by the use of the newly invented Uttmark's Plotting Chart which covers all Latitudes from 60° North to 60° South and all Longitudes, although less than *one square* foot in area, has a scale of 6 inches to one degree of Longitude; that is to say, 50 per cent. larger than the scale on the plotting chart published by the U. S. Hydrographic Office. The new plotting chart which is illustrated in the present issue of the "Wireless Age," I trust will be of help to the navigator and to the student of St. Hilaire's popular method.

The chart may be used for plotting ship's position by any method using the Sumner lines.



Uncle Sam's new five thousand ton concrete ship Faith, ten times larger than any constructed up to the present time



A. Ship's position by Dead Reckoning. B. Ship's correct position

Directions for the Sun, Moon, Planets and Fixed Stars

This chart can be used for all Latitudes from 60° North to 60° South and for any Longitude.

In **North** Latitude read the Azimuth from **North** to South over East or West according to the bearing of the celestial body. In **South** Latitude read the Azimuth from **South** to North over East or West, according to the bearing of the celestial body.

The **center** of the **large compass diagram** may generally be considered the ship's position by Dead Reckoning, and used in all Latitudes and Longitudes for which Mercator's Chart is constructed. The small auxiliary compass diagram may be used in extreme cases with an exceptionally long run between two solar sights.

The **miles** or **minutes** of Latitude are to be taken from the corresponding Latitude scale on the sides of the chart. For Longitude use the scale at top and bottom or center line of chart.

Although this plotting chart is specially designed for Marc St. Hilaire Method, it may be conveniently used for any other method when Sumner Lines are employed for finding the ship's position.

NOTE.—Lines of position or the Sumner Lines are always at right angles to the bearing or Azimuth of a celestial body.

(Patent applied for.)

(C) Press Ill Svce.

One of the largest naval training stations in the country is located at Pelham Bay Park, near New York, where this picture was taken of advanced students manipulating portable wireless apparatus and vacuum valve receivers

Navigation News

Shipbuilding Primer for Beginners

This question has often occurred to men in the shipyards, particularly volunteers from inland communities: "How can they expect us to build ships, when some of us never saw a ship?"

It is a pertinent and natural question, and the Industrial Service Department of the Emergency Fleet Corporation has answered it by means of the book prepared by A. W. Carmichael, Assistant Naval Constructor, U. S. N.

This book is a primer on shipbuilding. It tells the man in the shipyard what he is to do; why he is to do it, and how he should do it. A child can read it and become fairly familiar with the technical terms common to the seafaring man.

The ordinary landlubber may know what a mainmast and a smokestack and bridge on a ship are. He may even know what the rudder and stern and propeller and their functions may be, but not many will understand when you talk to them about the cargo booms, the bulwark, boat deck, poop deck or forecastle. Imagine his mystification when you ask such a man to describe a shell plating!

By reading this book, which is called "Shipbuilding for Beginners," the volunteer worker will not only know what these things are, but he will know why they are and how they are made.

The little volume should be a valuable asset in every shipyard in the country.

♣ ♣ ♣

A Huge New Concrete Vessel

A new chapter has been added to the romance of modern engineering, a story already replete with thrilling tales of man's triumph over the elements. An investigation conducted under the observation of the Emergency Fleet Corporation, involving construction of a large cargo-carrying concrete ship, opens up a new field that has possibilities of the most far-reaching importance. Success may mean a marked step toward victory over the German submarine.

In a shipyard at San Francisco has been launched the first large concrete vessel ever built in America, and, in fact, the largest ship of that construction ever built anywhere. This ship is an experiment, in so far as its size is concerned. There have been concrete ships built abroad, notably in Norway, but they were not so large. The vessel at San Francisco is of 5,000 tons.

If this ship is able to resist the strain of ocean traffic, which, it appears, is the big factor of doubt connected with the experiment, experts say that it will be the forerunner of many more concrete ships.

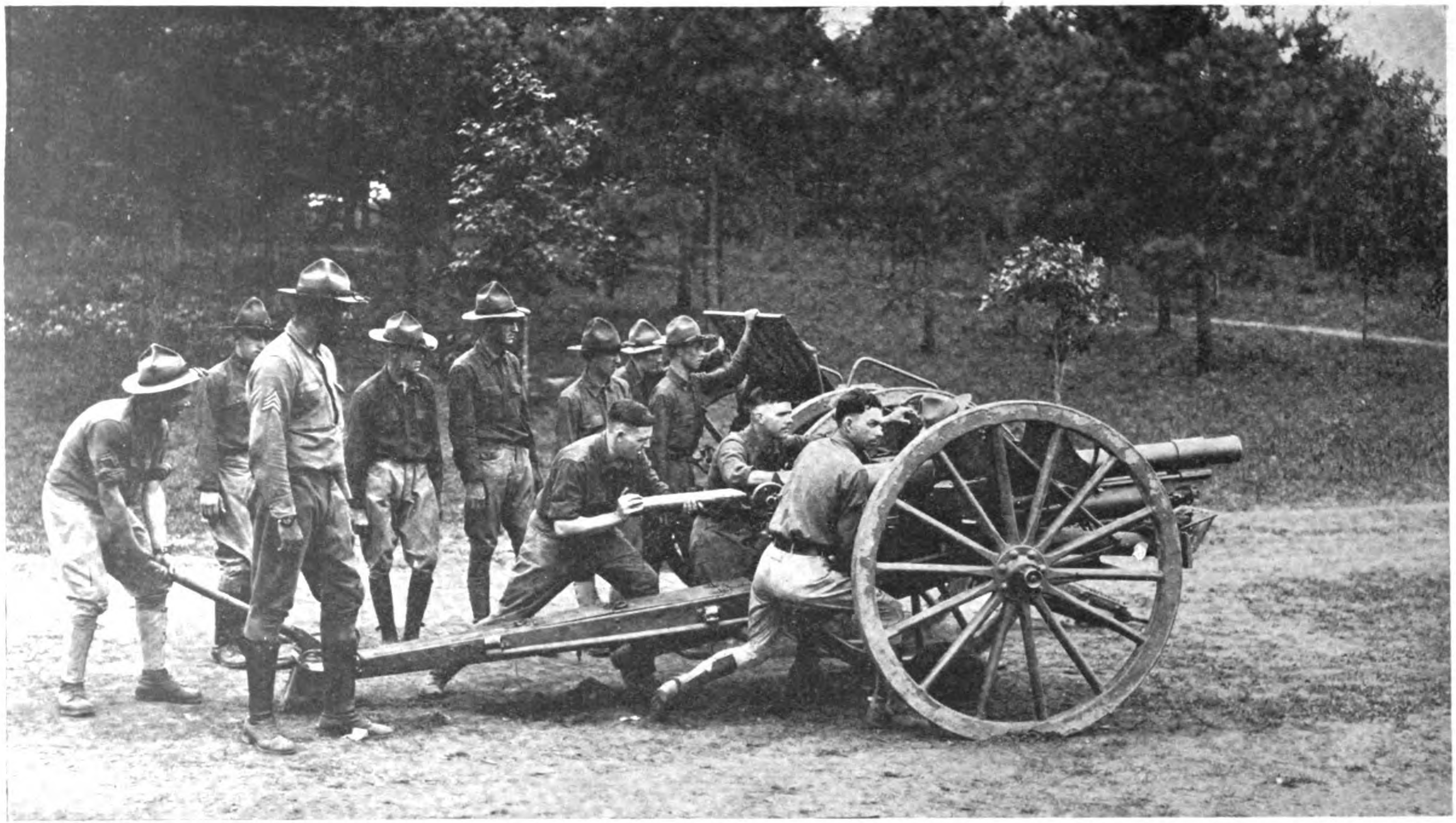

The bridge of ships to France

It is confidently predicted that, with concrete shipbuilding an established, practical and economical accomplishment, the Fleet Corporation will be able to build many such vessels and that they will go far to solve the problem of re-establishing American prestige on the high seas.

The vessel will be put to sea with a cargo before her builders will call the test complete. If she successfully passes the first tests to which she will be subjected, and so demonstrates the practicability of the experiment, it is quite likely that more ships of similar construction and size, or even larger, will be built.

Another concrete vessel, smaller than the one in the San Francisco yard, is being constructed by the corporation in a private yard at Brunswick, Fla. The Fleet Corporation rented one of the shipways in the yard and began building a 3,500-ton concrete ship.

The work is being done under the direction of the Department of Concrete Ship Construction, of which R. J. Wig, formerly of the Bureau of Standards of the Department of Commerce, is head. Mr. Wig went to San Francisco to witness the launching of the vessel built there.



Fire control by radio is one portion of the training of field artillerymen which is receiving special attention in the cantonments. The battalion radio officer responsible for accuracy of transmission of firing data is a second lieutenant, who receives advanced instruction. The photograph shows the 3-inch piece, correctly aimed in 20 seconds

Liberty Must Fight

AMERICA, entering a war for which her chief antagonist spent forty years in preparation, finds herself confronted with the necessity of a quick mobilization of every force within her industrial fabric including her man power. She can only meet Hun preparedness with industrial mobilization movements of a quickness, an intensity and of a size never before known in the history of the world.

Such a gigantic and necessary mobilization is the Third Liberty Loan, the campaign for which began on April 6.

Any man, woman or child who can read or listen while others are reading the authentic news prints of the day cannot escape the real conviction of the absolute necessity to civilization, to the United States and to each individual of our citizenship of the Third Liberty Loan.

The Hun has prepared the world and himself for conquest and a very definite extension of his Kommandanturs and Kultur throughout the world.

Readers of THE WIRELESS AGE know how thoroughly the forces of one of the newest arts and sciences have been utilized by the Hun in furtherance of a debasing of all the civilized world has held sacred. Officials of neutral countries and of peoples supposedly free have been corrupted for the purpose of allowing the establishing of wireless stations and the adjuncts to such stations which include secret service departments, poisoning squads, spreaders of germ diseases, and other practices which in a more primitive form have characterized barbarian warfare always.

We are told on the authority of perfectly authenticated observers in Belgium and North France that the German system there is perfect not only for repressing forcibly all manifestations of a national spirit but for actually attempting to win Belgians and French to German kultur.

Even the newspapers which were formerly published by the French in occupied parts of France have been taken over by the Germans. They are still published in French but with German editors who unceasingly attempt to point out to Frenchmen that they would be far better off under German barbarism.

There is ample evidence that such propaganda was long prepared under the direction of a department in Berlin and that the outbreak of the war found the German editors, with French educations, not far from the first forces which moved into Belgium and France.

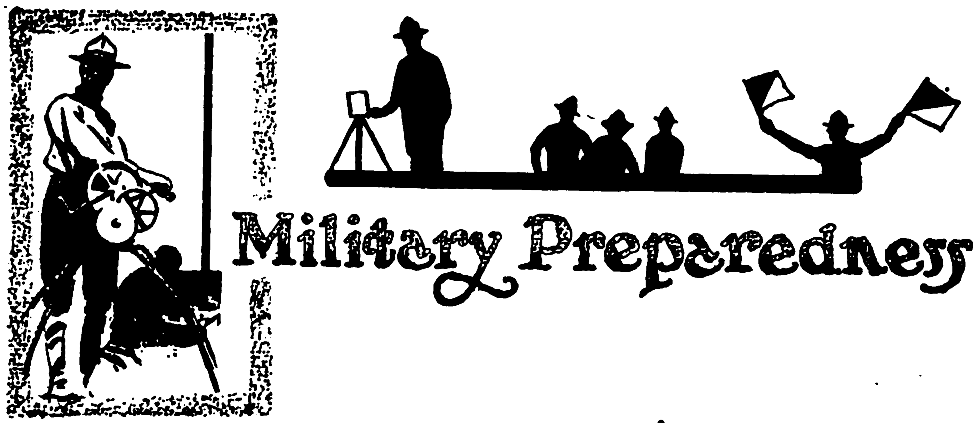
Such preparedness can only be combated through the medium of Liberty Loans. America must be completely mobilized industrially, for not only must she fight for herself and take the place of Russia in the great struggle but she must also feed and in large part materially equip her Allies.

If every man followed the rare example of the man who will not buy Liberty Bonds there would be no world in which the non-purchaser could live—only a No Man's Land with a German Kommandantur to which the unhappy remnant of a once great nation would be compelled to report his every act.

The full duty of every American at this time is not only to buy Liberty Bonds, but to talk them. The addresses of Four Minute Men are helpful to the cause, but after all, the really effective speech, the speech that brings the biggest results is that employed in convincing the individual.

(C) Underwood & Underwood

Aerial observers transmit their information by buzzer line and wireless to operators below. Wireless receiving sets of easy portability, such as shown in the illustration, being established at numerous points within the lines. With aircraft over the enemy positions sending while in rapid flight, the receiving task is no light one, requiring considerable skill on the part of the men engaged in this work



Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

TWELFTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, American Guard

The Heliograph

THE heliograph is an instrument designed for the purpose of transmitting signals by means of the sun's rays.

Description

The service heliograph equipment of the Signal Corps consists of:

A sole-leather pouch with shoulder strap containing—

1 sun-mirror, } Inclosed in a wooden box.
1 station mirror. }

1 shutter, 1 sighting rod, 1 screw driver.

A small pouch, sliding by 2 loops upon the strap of the larger pouch, containing 1 mirror bar.

A skeleton leather case containing 2 tripods.

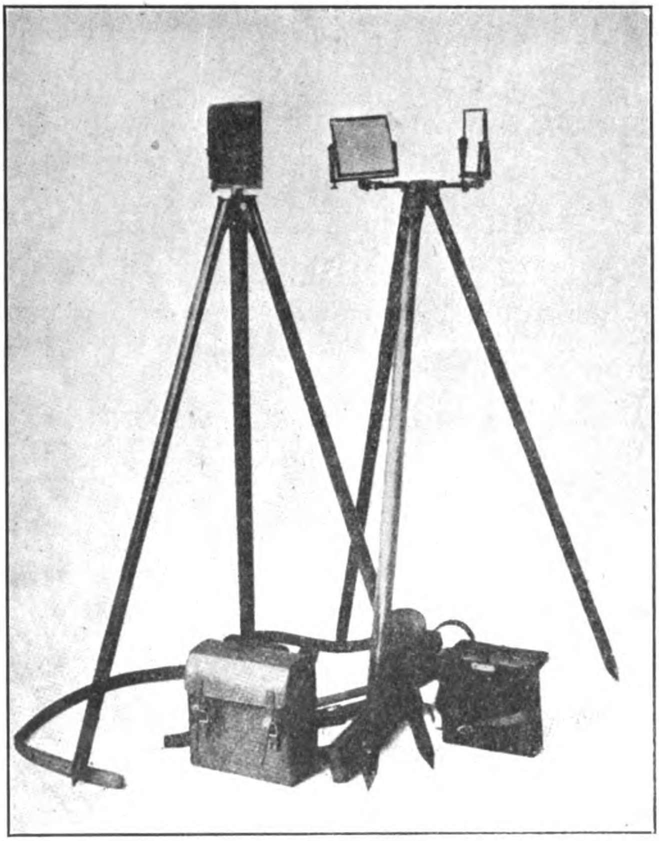
The mirrors are of plate glass, each 4½-inch square, supported by sheet brass and cardboard backings, and mounted in brass retaining frame. The sun mirror has a paper disk covering the unsilvered spot in its center. The mirror frames are carried by brass supports provided at the bases with conical projections accurately turned to fit the sockets of the mirror bar and grooved at the ends to receive the clamping spring. Each support is fitted with a tangent screw and worm-wheel attachment functioned to control the motion of the mirror-frame about its horizontal axis.

The mirror bar is a bronze casting provided at the center with a clamp threaded to fit the screw of the tripod. By releasing the clamp the bar may be

* The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author

moved independently of the screw and adjusted to any desired position. Conical sockets for the reception of the mirror supports are provided at the ends of the mirror bar. These sockets work freely in the bar and, being actuated by a tangent screw and worm-wheel, serve to regulate the motion of the mirror frame about its vertical axis. Clamp springs, for engaging and securing the ends of the mirror-frame supports, are attached at each end of the bar.

The shutter is 6½ inches square, six segments or leaves being mounted in such a way as to form a shutter. The leaves are designed to turn through arcs



The Heliograph assembled

of 90 deg. on horizontal axes, unanimity of movement being secured by connections made with a common crank bar. The crank bar is operated by a key and retractile spring which serve to reveal and cut off the flash. A set screw and check nut at the lower edge of the screen frame limits the motion of the crank bar and the opening of the leaves. A threaded base support furnishes the means of attaching the screen frame to the tripod.

The sighting rod is a brass rod 6½ inches long, carrying at the upper end a front sight and a movable disk. About the rod is fitted a movable bronze collar, coned and grooved to take the socket and clamping spring of the mirror bar. A milled-edge bronze washer serves to clamp the collar to the rod at any desired point.

The tripods are similar in all respects, the screw of either threading into the mirror bar or shutter frame. Each tripod is provided with a hook at the base of the head, allowing the suspension of a weight when great stability is required.

ASSEMBLING

There are two ways of assembling the heliograph, and the position of the sun is the guide in determining which of the two should, in any given case, be employed. When the sun is in front of the operator (that is, in front of a plane through his position at right angles to the line joining the stations) the sun mirror only is required; with the sun in rear of this plane both mirrors should be used. With one mirror the rays of the sun are reflected directly from the sun mirror to the distant station; with two mirrors, the rays are reflected from the sun mirror to the station mirror, and thence to the distant station.

With one mirror: Firmly set one of the tripods upon the ground; attach the mirror bar to the tripod; insert and clamp in the sockets of the sun mirror and sighting rod, the latter having the disk turned down. At a distance of about 6 inches, sight through the center of the unsilvered spot in the mirror and turn the mirror bar, raising or lowering the sighting rod until the center of the mirror, the extreme point of the sighting rod, and the distant station are accurately in line. Firmly clamp the mirror bar to the tripod, taking care not to disturb the alignment, and turn up the disk of the sighting rod. The mirror is then moved by means of the tangent screws until the "shadow spot" falls upon the paper disk in the sighting rod, after which the flash will be visible at the distant station. The "shadow spot" is readily found by holding a sheet of paper or the hand about 6 inches in front of the mirror, and should be constantly kept in view until located upon the disk. The shutter is attached to a tripod and established close to, and in front of, the sighting disk in such a way as to intercept the flash.

With two mirrors: Firmly set one of the tripods on the ground; clamp the mirror bar diagonally across the line of vision to the distant station; clamp the sun mirror facing the sun to one end of the mirror bar and the station mirror facing the distant station. Stooping down, the head near and in the rear of the station mirror, turn the sun mirror by means of its tangent screws until the whole of the station mirror is seen reflected in the sun mirror and the unsilvered spot and the reflection of the paper disk accurately cover each other. Still looking into the sun mirror, adjust the station mirror by means of the tangent screws until the reflection of the distant station is brought exactly in line with the top of the reflection of the disk and the top of the unsilvered spot of the sun mirror; after this the station mirror must not be touched. Now step behind the sun mirror and adjust it by means of the tangent screws so that the "shadow spot" falls upon the center of the paper disk on the station mirror. The flash will then be visible at the distant station. The shutter and its tripod are established as described in the single mirror assembling.

Alternate method with two mirrors: Clamp the mirror bar diagonally across the line of vision to the distant station, with the sun mirror and the station mirror approximately facing the sun and distant station, respectively.

Look through small hole in sun mirror and turn the station mirror on its vertical and horizontal axes until the proper disk on the station mirror accurately covers the distant station.

Standing behind sun mirror, turn it on its horizontal and vertical axes by means of the tangent-screw attachments until the "shadow spot" falls upon the paper disk on station mirror.

ADJUSTMENT

Perfect adjustment is maintained only by keeping the "shadow spot" uninterruptedly in the center of the paper disk, and as this "spot" continually changes its position with the apparent movement of the sun, one signalman should be in constant attendance on the tangent screws of the sun mirror. Movement imparted by these screws to the mirror does not disturb the alignment, as its center (the unsilvered spot) is at the intersection of the axes of revolution. Extra care bestowed upon preliminary adjustment is repaid by increased brilliancy of flash. With the alignment absolutely assured and the "shadow spot" at the center of the disk, the axis of the cone of reflected rays is coincident with the line of sight

This death-dealing pyrotechnic display is that which the Signal Corps man in the first line trenches faces in the long night preceding an attack at dawn. The remarkable view of No Man's Land given here graphically portrays the barrage fire which words cannot adequately describe

and the distant station receives the greatest intensity of light. Remember the distant observer is unquestionably the better judge as to the character of the flash received; and if, therefore, adjustment is called for when the "shadow spot" is at the center of the disk, the alignment is probably at fault and should be looked after at once. In setting up the tripod always see that the legs have a sufficient spread to give a secure base, and on yielding soil press firmly into the ground. Keep the head of the tripod as nearly level as possible and in high wind ballast by hanging a substantial weight to the hook. See that the shutter completely obscures the flash; also that the flash passes entire when the shutter is opened. This feature of the adjustment is partially regulated by the set screws attached to the shutter frame. The retractile spring should sharply return all the leaves of the shutter to their normal positions when the key is released. Failure to respond promptly is obviated by strengthening or replacing the spring.

OPERATION

It is of the utmost importance that uniformity in mechanical movement of the shutter be cultivated, as lack of rhythm in the signals of the sender entails "breaks" and delay on the part of the receiver. Dark backgrounds should, when practicable, be selected for heliograph stations, as the signals can be most easily distinguished against them.

To find a distant station, its position being unknown, reverse the catch holding the station mirror and with the hand turn the mirror very slowly at the horizon over the full azimuth distance in which the distant station may possibly lie. This should be repeated not less than twice, after which, within a reasonable time, there being no response, the mirror will be directed upon a point nearer the home station and the same process repeated. With care and intelligence it is quite probable that, a station being within range and watching for signals from a distant station with which it may be desired to exchange messages, this method will rarely fail to find the sought-for station.

The exact direction of either station searching for the other being unknown, that station which first perceives that it is being called will adjust its flash upon the distant station to enable it when this light is observed to make proper adjustments. If the position of each station is known to the other, the station first ready for signaling will direct a steady flash upon the distant station to enable the latter to see not only that the first station is ready for work, but to enable the distant station to adjust its flash upon the first station.

Smoked or colored glasses are issued for the purpose of relieving the strain on the eyes produced by reading heliograph signals.

CARE OF APPARATUS

Minor parts of the instrument should be dismounted only to effect repairs. Steel parts should be kept oiled and free from rust. Tangent screws and bearings should be frequently inspected for dust or grit. Mirrors should invariably be wiped clean before using. In case of accident to the sun mirror, the station mirror can be made available for substitution therefor by removing the paper disk. If the tripod legs become loose at the head joints, tighten the assembling screws with the screwdriver.

POWERS AND LIMITATIONS OF THE HELIOGRAPH

Portability, great range, comparative rapidity of operation, and the invisibility of the signals, except to observers located approximately on a right line joining the stations between which communication is had, are some of the advantages derived from using the heliograph in visual signaling.

The principal disadvantage results from the entire dependence of the instrument upon the presence of sunlight. The normal working range of the heliograph is about thirty miles, though instances of its having attained ranges many times greater than this are of record. The heliograph can be depended upon to transmit from 5 to 12 words per minute.

The Acetylene Lantern

The signal lantern is an instrument designed for the purpose of transmitting signals by means of intermittent flashes of artificial light. It is the standard night visual signaling equipment furnished by the Signal Corps and depends for its illumination upon the combustion of acetylene gas.

Acetylene

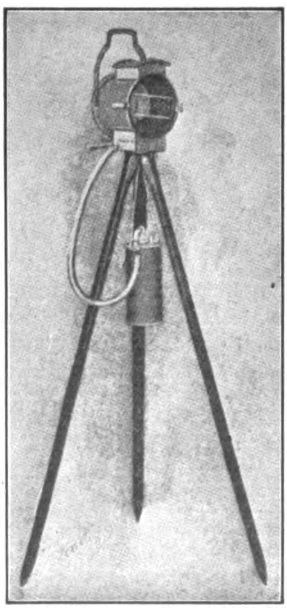
Acetylene is a pure hydrocarbon gas, producible in various ways, the commoner of which are: (*a*) By dropping calcium carbide into water; (*b*) by dropping water upon calcium carbide. This gas gives, when burning, high penetrative power, and was first described by Mr. Edmund Davy, professor of chemistry, to the Royal Dublin Society, in 1836.

Calcium Carbide

In the manufacture of calcium carbide for commercial purposes the best quality of coke and quicklime are used. These two substances are powdered thoroughly, mixed in proper proportions, and then placed in an electrical furnace. Under the action of the intense heat (5,500 deg. F.) these two refractory substances unite and form calcium carbide. Calcium carbide is of a grayish-white color, crystal in appearance, and is nonexplosive and noncombustible, being, except for its affinity for water, an absolutely inert substance.

When calcium carbide is brought in contact with water the following occurs:

As is known, the principal components of water are oxygen and hydrogen, and calcium carbide is calcium and carbon. When brought in contact, the oxygen in the water decomposes the calcium in the carbide, and in this decomposition the hydrogen in the water is liberated and unites with the carbon of the carbide, forming a hydrocarbon gas, which is acetylene. It gives a pure white light of intense brilliancy and high candlepower. The spectrum analysis of acetylene shows that it is almost identical with sunlight, and in consequence delicate shades of color appear according to their true value as under the light of the sun, consequently it penetrates fog to a greater distance than other lights. Acetylene is like other gases—explosive when mixed with air in proper proportion, confined, and ignited—and the same precautions should therefore be taken in its use as would be in the handling of coal or water gas, gasoline vapor, etc. As acetylene is very rich in carbon, it will not burn in its pure state without smoking. To avoid this, burners have been constructed so that the gas is mixed with the proper proportion of air at the burner tip, to insure perfect combustion. The burners for acetylene are different from those for other gases. In order to get a flat flame, the gas is brought through two perfectly round holes at an angle which causes the two flames to impinge upon each other and thus form a flat flame.



Signal Lantern assembled

Method of Gas Generation

The method employed for producing acetylene in the signal lantern is by bringing water into contact with the calcium carbide. The disadvantage of this method is that when the water is not in excess and does not entirely surround and touch each piece of carbide the heat of generation will so change the chemical properties of the gas that combustion at the burners is not satisfactory.

This change is technically known as "polymerization," or the breaking up of acetylene into other hydrocarbons, such as vapors of benzine, benzole, etc. These form a tarry substance which is apt to condense at the burner tip and clog the openings. Also they deposit carbon on the burners, as they require more air for perfect combustion than does pure acetylene. Another disadvantage of this system is that after the carbide and water are in contact, generation of gas will continue until all the water is absorbed. Where, however, portability of the generating apparatus is desired and resort to this method is necessary, the objections are not important, if the apparatus is well constructed and care is taken in its use.

Description

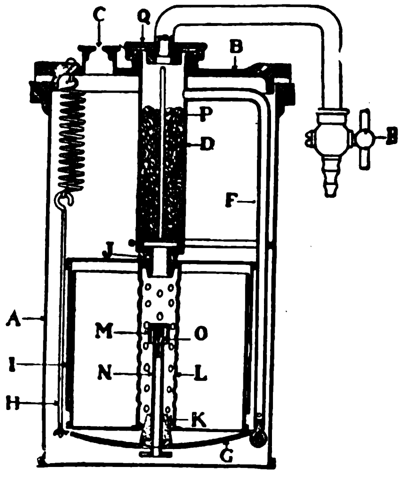
This equipment consists of a signal lantern with cartridge generator attached. The lantern is fitted with a special aplanatic lens mirror, 5 inches in diameter and about 3 inches focus. The lantern is packed complete in a wooden case with shoulder straps and the following extra parts are included, each part having its own receptacle in the case: 2 burners, 1 cover glass, 3 cartridges of calcium carbide of 5 ounces each, 1 pair of gas pliers, 1 tube white lead, 1 extra filter bag, 1 screwdriver.

The lantern is made of brass, all parts of which are riveted. The burner is of the double tip form. The lantern is fitted with a hood to provide proper ventilation and at the same time to prevent the flickering of the light by the wind. The front door of the lantern is hinged and fastens with a spring clasp; it is so arranged that it can be entirely removed if necessary. The cover glass is made in three sections and is not affected by the expansion and contraction of the metal due to changes in temperature. The glass is fastened by the aid of a spring wire, so that it can be readily removed if it is necessary to replace a broken section. In the base of the lantern is a key and the adjustment for regulating the height of the flame. The key is so arranged that when not depressed but little gas is admitted through to the burner, which gives a bright flash. At the back of the lantern there is an adjustable handle, so that the equipment can be used as a hand lantern if desired. This form of lantern can be used with the regular heliograph tripod, the generator being either attached to the back of the lantern or suspended, as shown in the photograph. When practicable it is better to attach the generator to the lantern, as shown in the smaller view. The candlepower of this lantern is about 1,900.

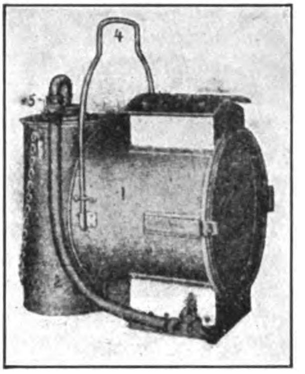
The Generator

The generator used is known as "the cartridge generator," and while constructed on the water-feed principle, the disadvantages incident to this method are eliminated as far as possible. It is constructed of brass and has a removable top. Attached to the inside of the top is a flexible frame with a spring latch, the spring latch being hinged. At the top of the frame is a tube or cylinder, the bottom of which is conical in shape and covered by a rubber plug. At the bottom of the frame is a hollow tube, which is the water inlet. The cartridge proper consists of a tin cylinder having an opening at either end. A small cylinder of wire mesh extends from and connects these openings. The carbide lays around this mesh on the inside of the cartridge. The rubber plug before mentioned fits into the upper opening and the water tube into the lower opening. Inside the tube, at the top of the frame, is a filter, the function of which is to remove the dust and moisture from the gas. The outlet from this chamber is by a brass bent tube having a stopcock attached thereto.

The drawing gives a sectional view of the generator with the cartridge in place. *D F G H* represent the valve frame and *I* the cartridge attached. The reservoir *A* is filled with water, and when the frame is immersed, with the valve *R* closed, the air contained in the cartridge and tubing cannot escape, the water seal preventing, while the confined air prevents the water from rising in the tube *N*. When the valve at *R* is opened and the air is allowed to escape, part of the water from the reservoir rises into the tube *N* and then out through the small hole *O* to the carbide. Gas is immediately generated, the pressure of which prevents further ingress of the water from the tube *N*, and the generation of gas is suspended.



Signal Lantern Generator



Signal Lantern with cartridge generator attached. The lantern is fitted with an aplanatic lens mirror and has a candlepower of 1900

As the gas passes out through the valve at *R* the pressure decreases, permitting the water to again rise in the tube and flow through *O*. Gas is again generated, which at once exerts its pressure and cuts off the supply of water. This is the automatic action by which water is brought in contact with the calcium carbide. Thus it will be observed that the use or escape of the gas regulates the generation by the simple device of the rise and fall of a water column. There is a cap *M* screwed over the tube *N*. This is used to deflect the course of the water downward, so that the carbide in the lower part of the cartridge is first attacked. There is a needle inside of cap *M*, which can be used for cleaning the hole *O*. When the gas is generated it passes through the filter *D* on its way to the burner through *R*. This filter consists of a tube loosely packed with ordinary nonabsorbent cotton, which should never cover the escape pipe leading to the valve *R*. In passing through this cotton filter moisture and dust are removed from the gas. In the latest model a felt filter is used instead of cotton.

The escape pipe *F* provides a means for the escape of gas generated and not used, or generated more rapidly than consumed. Should an excess be generated, it passes down through the tube *F*, and, finding its way through some small holes in the bottom of this tube, escapes through the water seal and the opening at *C*. It will be noted that if escaping gas at *C* should become accidentally lighted, the flame cannot strike back into the filter and cartridge because of the water seal. The principal things to observe in the operation of this generator are the following:

(1) To see that the rubber plugs *fit tightly* into the openings of the cartridge.

(2) That the tube *N*, the cap *M*, and water hole *O* are not stopped up.

(3) That the cotton in the filter is changed frequently.

(4) That the *stopcock R is closed before inserting the frame in the water.*

If this latter instruction is not complied with, it can be readily seen that the water will have free access to the carbide and excessive generation will occur.

When the charge is exhausted the entire cartridge is taken out and thrown away. This eliminates the handling of carbide and the disagreeable task of cleaning out the residuum after the gas has been extracted.

Connection is made from the stopcock *R* to the hose connection on the lantern proper, and this is the passageway of the gas from the generator to the burner. As soon as the stopcock is opened the water rises through the tube and flows to the carbide. The advantage of the cartridge being submerged in the water is to reduce and absorb as much of the heat liberated by generation as is possible.

Powers and Limitations of the Acetylene Signal Lantern

As conditions are usually more uniform at night than in the daytime, the signal lantern is probably with the exception of the searchlight the most reliable of all means of visual signaling. The advantages of this apparatus are its portability, speed of operation, and comparatively great range. The principal disadvantages are due to the interference caused by rain, fog, and moonlight. The speed attainable with the lantern is about the same as that attainable with the heliograph. In emergency, and for distances not exceeding ½ to ¾ mile, the lantern can, on dark or cloudy days, be employed for day signaling. These lanterns have been tested up to a distance of 10 miles with the naked eye; and under favorable conditions can be used over a range somewhat in excess of this. With a 30 power telescope, the flash can be read at 30 miles.

Technical Equipment of Personnel

The technical equipment for men of a field company, Signal Corps, is as follows:

(a) Each enlisted man carries on the person one electrician's knife, one pair of 5-inch pliers.

(b) *Chiefs of sections* carry, in addition to (a), 1 field glass, Type D, a wrist watch, map case and map, a field message book, a pencil and a compass.

(c) *Operators* carry, in addition to (a): Of wire sections—1 field buzzer (when not carried on the wire cart), 1 connector, buzzer, 1 ground rod, 1 wrist watch, 1 field message book, and 25 message envelopes, 2 pencils, 1 small roll of tape, 1 cipher disk. Of wireless stations—1 wrist watch, and also field message books, 25 message envelopes, 2 pencils, cipher disk and tape in the pack chests.

(d) *Linemen* carry, in addition to (a), 1 wire pike, 1 cavalry buzzer, 1 connector, buzzer, 1 ground rod, 1 carrier with buzzer wire, 1 small roll of tape. The pike is not carried at ceremonies except at mounted inspection.

(e) *Messengers* carry, in addition to (a): Of wire sections—1 field message book, 1 pencil, 1 small roll of tape, 1 box of wind matches, and, when not carried on the wire cart, a lantern, 3 candles, and box of wind matches. Of wireless sections—1 field message book, 1 pencil.

(f) *Horseholders (dismounted: line guards)* carry, in addition to (a): Of wire sections—1 small roll of tape, and, when not carried on the wire cart, a lantern, 3 candles, and a box of wind matches.

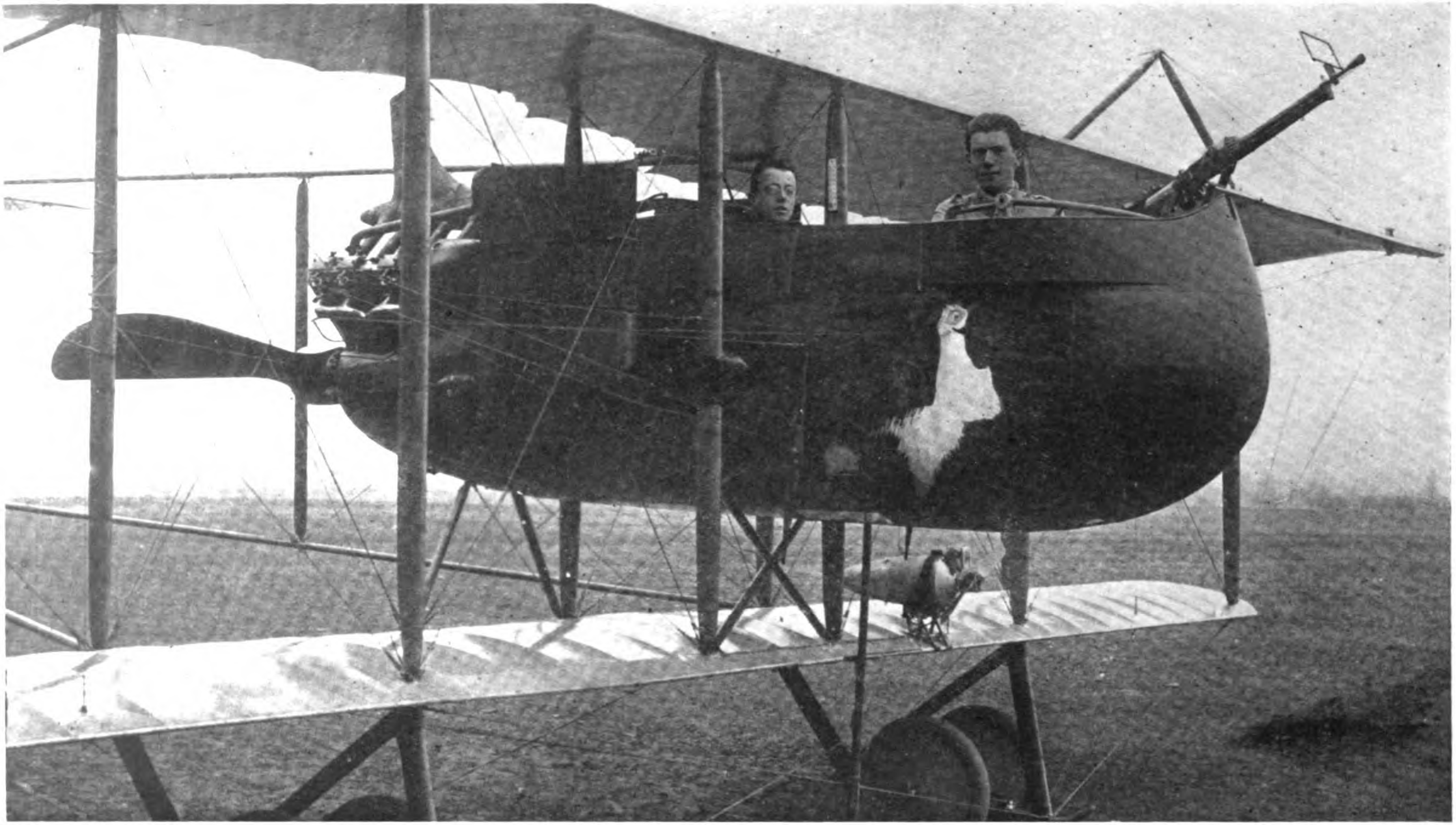
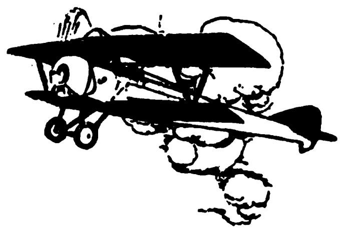


Photo Kadel & Herbert

A French observation plane, showing the location of pilot and observer in the nacelle, the mounting of the machine gun and, on the lower wing, the generator for the wireless set rotated by wind action against the miniature propeller

How to Become an Aviator

The Tenth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE

Author of "Text Book of Naval Aeronautics"

CONTINUING the subject of aviation engines, a few considerations may be noted, preliminary to the study of pistons, valves and carburetors. First, is the refinement of design necessary for aeronautical work. The aviation engine, unlike those of motor cars, ordinarily uses 75 per cent. of its horsepower, as against one-quarter usage in motor cars. A second consideration of design is the necessity for building an aviation engine as light as possible, yet the punishment of material within the engine structure is about fourteen times as severe as in the motor car. The effect is demonstrated in the respective lives of both types. A motor car engine generally runs up to a mileage of 25,000, at a maximum average speed of 25 miles per hour, or completes 1,000 hours operation before overhauling is necessary. The aviation engine, with a speed of 100 miles per hour, requires a complete overhaul in about 50 flying hours, a total of 5,000 miles, or one-fifth of the motor car's period of operation.

These comparisons broadly illustrate the relative severity of the two types of engine service. But although it is required that the aviation engine be of light construction, strength must not be sacrificed in vital parts. While light weight is the aim in designing the crankshaft and crank case, main bearings, crank and piston bearings, strength is maintained by very careful selection of materials.

An aeroplane required to make climbs of 20,000 feet must necessarily have perfect reliability of operation. The structure of the aircraft is obviously sensitive to vibration and an engine which does not function smoothly materially impairs flight efficiency. Irregular impulses of the engine also affect its light structure and uniform explosions are a requisite. This uniformity is gained only through perfect distribution of gas to the cylinders.

The student should keep these conditions in mind as the study of vital parts of the engine is continued.

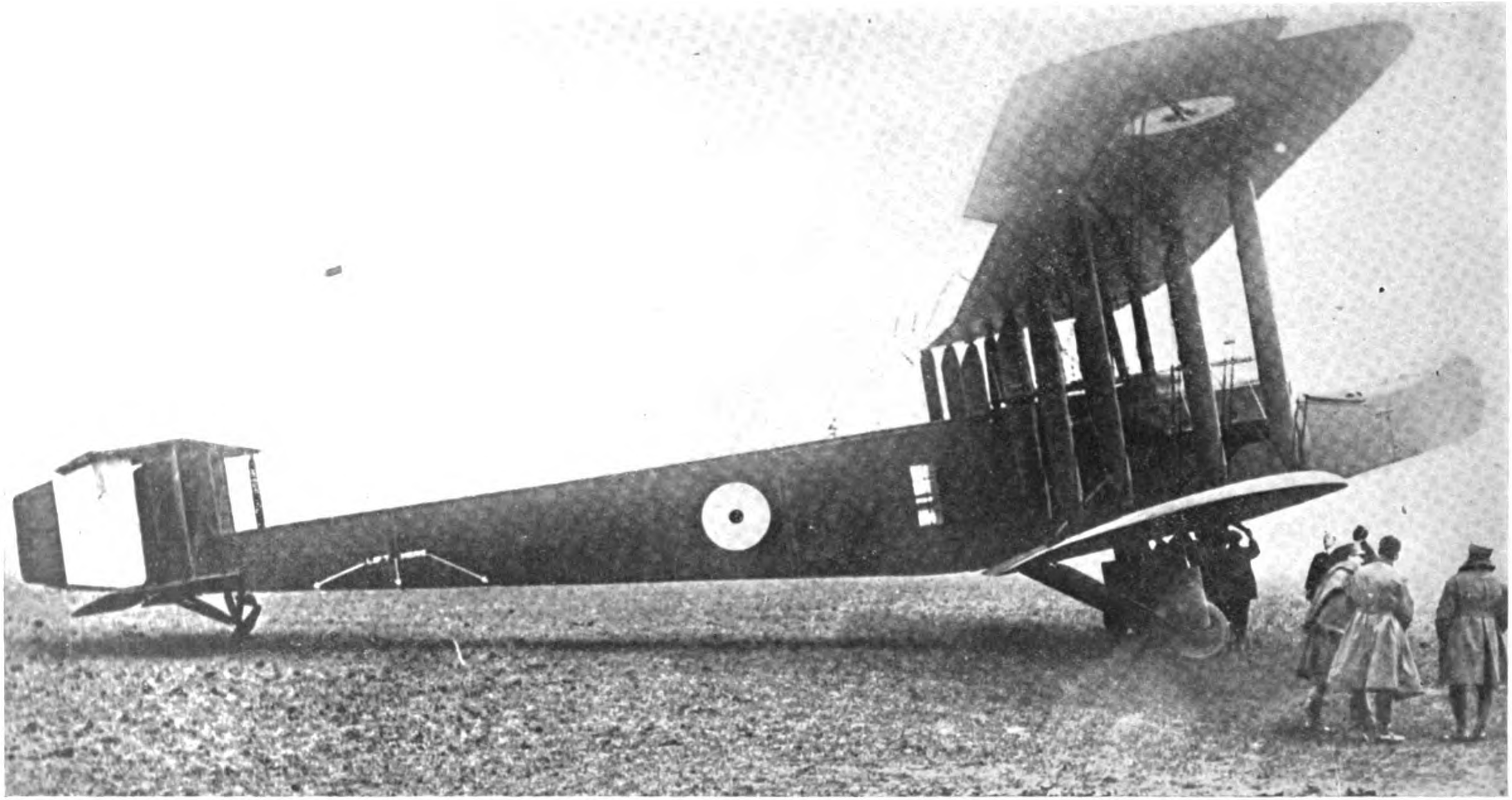


Photo Central News

Interest in American aircraft production centers about the announcement that the Handley Page heavy bombing plane, here illustrated, has been adopted. This leviathan of the air carries as many as six men and eight machine guns

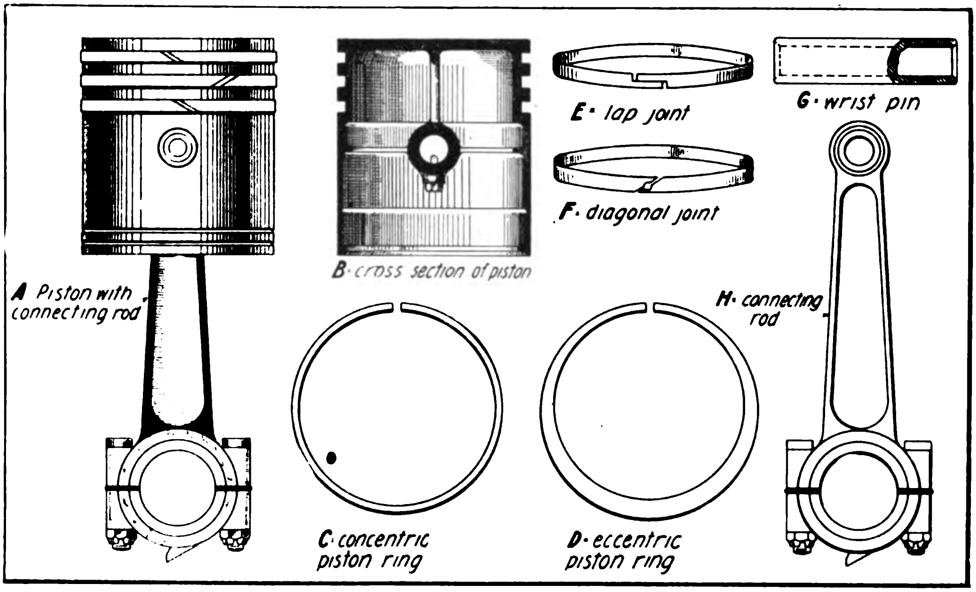


Figure 53—Details of the piston and connecting rod

PISTON

Although one of the simplest parts of the aeroplane motor, the piston is one of the most important, as it receives the full force of the explosion and transmits the gas combustion into power.

In construction, it shows only slight variations in the numerous types of engines; the most common form of construction is shown at A and B in figure 53. The piston is made usually of cast iron, steel or aluminum, machined to fit the cylinder diameter with a clearance of .005 to .010 of an inch to compensate for the expansion of heat and permit lubrication between it and the cylinder walls. The clearance varies with the designed speed of the motor, increasing for the higher speed motors in which greater friction is created. Channels are cut in the outer face of the piston wall, near the top; in these the piston rings are placed.

PISTON RINGS

These are split rings of cast iron, sprung so as to bear tightly against the wall of the cylinder to prevent leakage of gas from the combustion chamber and the passage of lubricating oil into the explosion area. Two types are shown at C and D in figure 53, and the common forms of expansion joints at E and F.

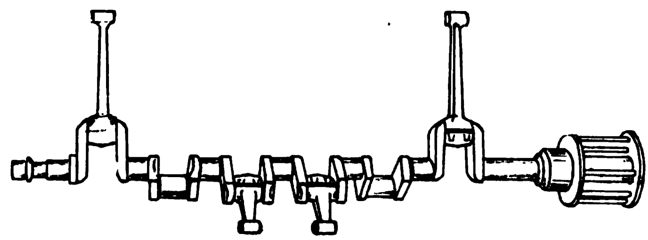
CONNECTING ROD

The connecting rod joins the piston to the crankshaft and transmits the motion to the latter as the piston travels up and down. It is usually made of drop forged steel, I-beam construction.

A typical connecting rod is shown at H in figure 53, which indicates the two bearings, the upper, of bronze, connected to the wrist pin, and the lower bearing, through which the crank shaft passes, usually split and made of a bronze base with babbitt metal carefully scraped to exact clearance.

WRIST PIN

This fitting, also known as the gudgeon or piston pin, joins the piston to the connecting rod. As shown at G in figure 53, it is a simple cylindrical element, usually made of steel and fitting the bosses closely.



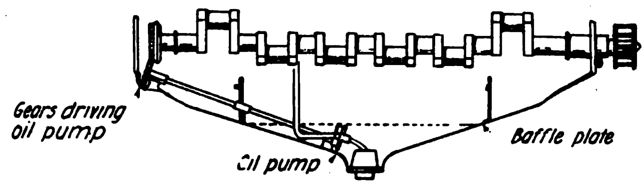


Figure 54 (*upper*)—*Crankshaft of* 6-*cylinder engine*

Figure 55 (*lower*)—*Lower section of crankcase with shaft in position*

CRANKSHAFT

As the main drive shaft of the motor, the crankshaft is subjected to greatest strain; it is therefore ordinarily made of high tensile steel, drop or machine forging. It is constructed as a bar having U-shaped offset arms, or crank-throws, one for each cylinder for attachment to the connecting rods. It is usually drilled for oil ducts and hollowed to reduce weight, yet is of requisite strength to withstand the continuous shocks it sustains.

A crankshaft for a 6-cylinder engine is shown in figure 54, connecting rods being indicated and the propeller hub and flange shown at the right end. The opposite end carries a gear which meshes with a system of gears to transmit motion to the crankshaft, magneto, oil pump and other auxiliary parts.

In the illustration provision is made for mounting the propeller on the crankshaft for direct drive, in which case a flywheel would not ordinarily be used. Because the speed of the motor is generally considerably higher than the most efficient number of revolutions per minute of the propeller, reduction gears are commonly introduced at the propeller end of the crankshaft where the motor speed exceeds 1,400 revolutions per minute.

CRANKCASE

The crankcase is usually made of aluminum alloy, in two parts, the upper, to which the cylinders are bolted, and the lower containing the crankshaft and lubricating oil. It contains the crankshaft bearings, or seats in which the center line of the crankshaft is supported. These mountings are usually made of babbitt or other high anti-friction metal.

Figure 55 shows the lower half of a typical crankcase for a 6-cylinder engine, the shape of the case conforming to the type of the motor in each instance.

(C) Comm. Pub. Info.

Student aviators of the U. S. Signal Corps closely examining the assembly of the carburetor on an aviation engine

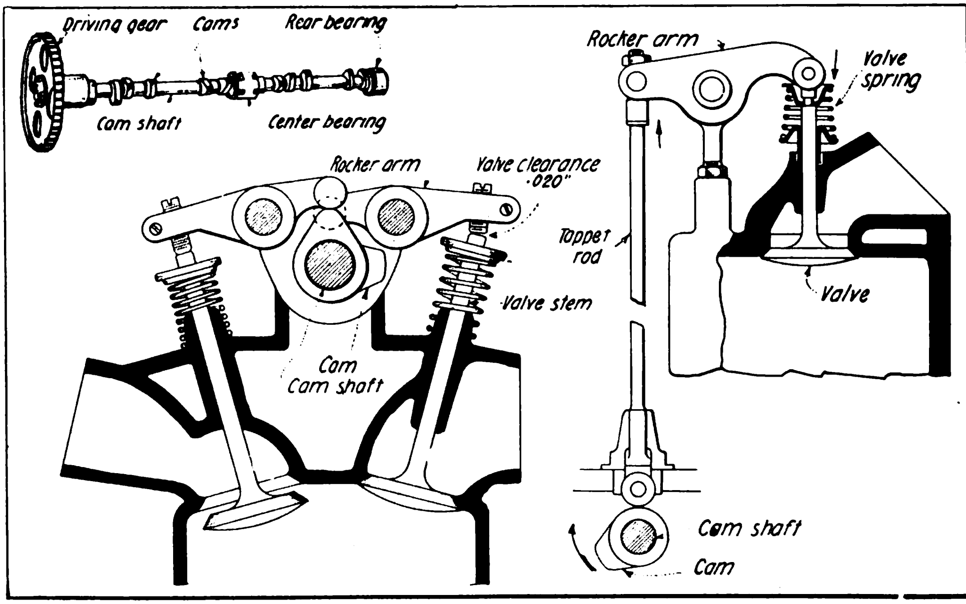


Figure 56 (upper left)—Camshaft, showing the driving gear and cams
Figure 57a (lower left)—Valve operating mechanism for overhead valves
Figure 57b (right)—Valve operating mechanism where camshaft is at base of motor

CAMSHAFT

The shafts for operating the cams, or irregularly curved lugs, which operate the valve mechanisms are known as camshafts. The material generally used is open hearth or drop-forged steel; the bearings are of bronze. Camshafts are drilled to reduce weight.

Two methods of driving or rotating the camshaft are employed, the most common being by means of gearing, a simple spur gear such as shown at the left of figure 56 being employed when the camshaft is horizontal, or parallel to the crankshaft, from which it obtains its motion at half-speed.

Operation through use of a chain drive in the form of link belts over toothed pulleys, is the second method, recently come into some favor through its use in foreign engines.

CAMS

A cam is a lug cast integrally on the crankshaft and machined to a form resembling a circle, with an approximately triangular projection at one point. It is this projection which acts on the valve mechanism as the shaft rotates.

Figures 57 a and 57-b show cams operating on overhead valves, the former acting direct on rocker arms and the latter through the medium of a tappet rod. Both intake and exhaust valves are operated by the same camshaft in general practice, although many exceptions are made in engines which have separate camshafts for intake and exhaust valves.

VALVES

In almost every instance, aviation motors have valves placed in the head of the cylinder, or overhead valves, thereby gaining increased power. The valves are opened by the mechanism operated by the camshaft and closed by springs.

VALVES AND VALVE MECHANISM

EXHAUST VALVE

Exhaust valves are generally made of tungsten steel, which has the necessary high resistance to the heat of the exploded gases which pass through the exhaust. The disk and valve seat are beveled and ground so that the valve is gas-tight when seated.

Theoretically, the exhaust valve is opened only during one of the four cycles or phases of the engine's operation, that is on the upward exhaust stroke. In practice, however, it is usually opened as soon as the piston has moved downward through about seven-eighths of its power stroke, or ½ inch from bottom dead center. It closes exactly at the finish of the exhaust stroke, or in some cases it is allowed to remain open until the piston has moved down about 1-20-inch on its intake stroke, so that all exhaust gas has a chance to escape.

The exhaust ports are of proper dimensions, varying with type of engine, to insure rapid and complete expulsion of the burnt gas. Exhaust manifolds are seldom used as they retard this expulsion, but short pipes are common, permitting the gas to exhaust into the open air but carrying it away from the aviator's face, and reducing the danger from fire.

INLET VALVE

High nickel steel or cast iron are the materials generally used for inlet valves. The construction of valve and seat is identical with the exhaust valves, usually beveled and always ground so as to be leak-proof when closed.

It is timed to open as the piston has descended about ⅛-inch on its intake stroke and remains open until the piston has traveled about ⅛-inch up on the compression stroke. This permits the cylinder to fill with gas, the downward drive of the piston creating a suction which will remain stronger than the slight upward pressure created during the 200th part of a second in which the valve remains open as the upward compression stroke begins.

VALVE OPERATING MECHANISM

Valve-in-the-head motors gain flexibility by offering no resistance to the entrance of gas into the combustion chamber, or impediment to straight exhaustion. But the valve opening mechanism is somewhat more complicated than that used in T-head or L-head cylinders. In place of the direct push rod action from the cams employed by the latter, the valve in the head motor secures its opening of valves by the system of rods and rocker arms illustrated in two forms, respectively in figures 57-a and 57-b.

In figure 57-b, the camshaft is located at the base of the cylinders, or at the crankcase, being rotated by bevel gears at half speed from the crankshaft. The cam pushes up the tappet rod, raising the rocker arm at one end which pushes down the valve attached to the other.

Figure 57-a shows a form of construction which places the camshaft above the cylinders, where it is driven by bevel pinion and gear drive by a vertical countershaft from the crankshaft. This form of construction is being adopted by many American aviation engine manufacturers, since it does away with the tappet rods and simplifies the engine construction.

All valves are closed by the action of the spring, as clearly indicated in the drawings.

VALVE CLEARANCE

Space must be left between the valve stem and the actuating means, the amount of clearance depending upon the design of the engine. The clearance is indicated as .020 inch in figure 57-a, where the valve stems are long; in the Curtiss 0X2 engine the clearance is .010 inch, or half, the variation being due to the amount of valve area which becomes heated and expands in length when the engine is running.

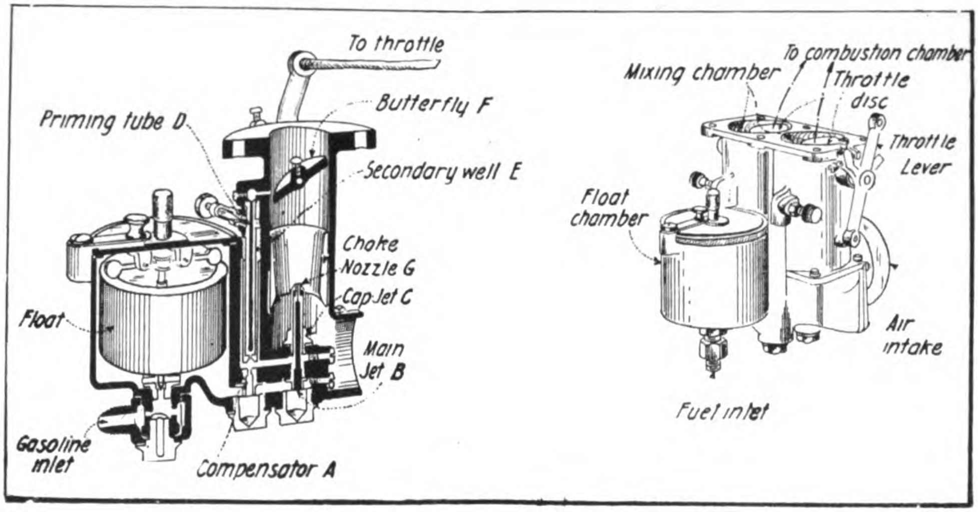


Figure 58 *(left)—Sectional view of carburetor showing details of the compound nozzle and compensator*

Figure 59 *(right)—The duplex carburetor for multiple cylinder engines*

CARBURETION

Gasoline will not burn unless it is mixed with air. To burn with great rapidity and heat, or to "explode," as required by the internal combustion engines of aviation, the air must be in correct proportion to the gasoline vapor; these proportions range from 18 to 20 parts of air to one of gasoline. The vapor is produced by exposing the liquid to the air, generally by spraying into a mixing chamber.

PRINCIPLE OF THE CARBURETOR

The device in which the vaporizing of gasoline is performed is termed a carburetor. There are numerous types used on aeroplanes, but the standard construction calls for: (a) a float chamber to maintain the gasoline at a constant level, (b) a mixing chamber where the gasoline is sprayed through a nozzle and mixed with incoming air. In the form of vapor it is then drawn through the inlet valve into the cylinder by the suction of the down stroke of the piston. The throttle valve, or butterfly, generally placed above the spray nozzle in the mixing chamber, regulates the amount of gas entering the cylinder; this valve is controlled by a lever near the pilot's seat. The speed of the engine increases with the opening of this throttle and decreases accordingly as it is closed. A float with a needle valve cuts off the flow of gasoline when the engine is not running.

CONSTRUCTION OF THE CARBURETOR

Figure 58 is a sectional view of the Zenith carburetor, selected as typical of the best construction and widely used in American aviation engines. By a compensator and compound nozzle principle, this carburetor maintains a constant ratio of air and gasoline at the most efficient combustion mixture.

The advance in design here represented is the elimination of variable air valves or moving parts. The construction is clearly indicated in figure 58. Gasoline from the float chamber is admitted at compensator A into the priming tube D, extending into the secondary well E, and opening at the priming hole uncovered by the action of the butterfly valve F. The suction at the priming hole is powerful and with the butterfly partly open the well full of gasoline is drawn into the cylinders, effectively priming the motor. At high speeds with the butterfly opened further the priming well ceases to operate and the compound nozzle drains the well. It is this feature of the Zenith carburetor which counteracts the defects of the vaporization at the nozzle of the conventional carburetor when the engine is operating at low speed. To illustrate: In the conventional single jet carburetor the gasoline enters by suction through main jet B, spraying from nozzle G in the path of air entering through the inlet at the lower right of the drawing, figure 58. As the speed of the motor increases, the air flow increases, but the law of flow of liquid bodies makes the flow of gasoline from the jet increase faster, giving a mixture which increases the percentage of gasoline, or becomes richer. By the introduction of the secondary well E, the gasoline is fed through the compensator A and is not affected by the suction, since the well is open to atmospheric pressure. The flow of gasoline is therefore made constant at all speeds, it being obvious that as the air intake increases with greater speed, the mixture becomes poorer. The combination of the two results in a carburetor giving a constant mixture.

DUPLEX CARBURETOR

For multiple cylinder aviation engines, arranged in V form, which will be discussed later, it was found that the strong cross suction in the inlet manifold made good carburetion difficult with a single carburetor. The development of the duplex carburetor, shown in figure 59, followed. It provides two separate mixing chambers, fed by a common float chamber and permitting each set of cylinders a separate intake.

MANIFOLDS

As the gas mixture passes upward and out of the mixing chamber it reaches the cylinders by way of pipes divided into branches built to accommodate the model of motor, and termed manifolds. The branches of the manifold are of the same dimensions, so as to obtain the same results for all cylinders and are free from sharp bends or obstructions which might retard the progress of the gas to the cylinders.

In the eleventh article of the series, which will appear in the June issue, ignition, cooling and lubrication of aviation engines will be considered.

MILITARY AIRMEN

CAPT. JAMES C. McCOY

Prominent Balloonist and Former Militia Officer Whose Knowledge of Aeronautics Antedates the Use of Airplanes Now in Army Service.

WITH the outbreak of the war, James C. McCoy was one of the first aviators to place his knowledge of aeronautics at the disposal of the Government. Recognizing the value of his long and varied experience, he was commissioned Captain in Aviation Section, Signal Corps. He had previously served in the Militia of the State of Colorado, where he held the rank of major.

Captain McCoy was among the first to take up ballooning in the United States, long before the days of heavier-than-air craft. He purchased one of the first aerostats to be used in the international races, and soon distinguished himself for his skill and fearlessness. Among the many thousands of men holding air pilot licenses today, Captain McCoy has the unique distinction of having been granted the first Spherical Balloon Pilot Certificate issued by the Aero Club. He is a charter member of the Aero Club of America, served on the Contest Committee for many years, was its president in 1908, and afterward a member of the Board of Governors.

More than ten years ago Captain McCoy, accompanied Lieut. Col. Charles de F. Chandler, U. S. A., when he won the Lahm Trophy. The flight, which lasted twenty hours and fifteen minutes, starting from St. Louis, covered 473 miles, the landing being made in West Virginia. He entered the second Gordon Bennett International Balloon Race in 1907, and afterwards ordered the best balloon that could be built, to be called the "America II," with which he entered the third Bennett race held in Berlin in 1908. This balloon was loaned to E. W. Mix, who entered it in the fourth international race which started from Zurich in 1909, winning the contest with a flight of 698 miles.

This famous balloon, which continued to be the personal property of Captain McCoy, was afterwards loaned to Allan R. Hawley, president of the Aero Club, who won the national balloon race, starting from Indianapolis in 1910; and afterwards the Fifth Gordon Bennett race, starting from St. Louis, when it made the remarkable record of 1,172 miles. The balloon was left in the wilds of Canada where it came down, but was afterwards rescued and participated in subsequent balloon races. Captain McCoy is not only one of the pioneers in the science of aeronautics in America, but has kept pace with its rapid development.

Aviation News

New York Trains Draft Men in Aero Repair Work

The Board of Education of New York City has started classes in repair work for the aviation service. The work is under the auspices of the Evening Schools, of which Henry E. Jenkins is in charge. The men will be taught how to reproduce, repair and assemble various parts of the airplane.

Only drafted men of Class 1 and 2 and who have had at least one year of experience in a mechanical trade necessary for aircraft work are qualified.

Ten classes to reproduce and repair the wooden parts necessary for an airplane have been organized. Two hundred and fifty men are taking this course. Six classes in engine repair work are now in operation, and several classes have also been organized in canvas work.

♣ ♣ ♣

10,000 Skilled Men Needed by the Aviation Section

The Signal Corps has authorized the following statement:— Ten thousand machinists, mechanics, chauffeurs, and other skilled workers are needed at once by the Aviation Section, Signal Corps.

The present call for 10,000 men is to fill an immediate need and may be regarded as the precursor of others as the service is being built up. Even at that the actual strength of the service to-day is over one hundred times what it was on April 1st last year.

Men registered in the draft may be inducted into this service by applying to their local draft board. Men not registered may enlist at any recruiting office. Further information may be had by applying to the air division, Personnel Department, Washington, D. C. In either case they will be sent to San Antonio, Tex., for segregation by trades, followed by a brief course of instruction at the flying fields or at various factories and organized into squadrons mostly for service over-seas.

The present call is especially for machinists, auto mechanics, engine repairmen, gunsmiths, chauffeurs, carpenters, blacksmiths, tinsmiths, cabinetmakers, electricians, coppersmiths, sheet-metal workers, propeller makers, wireless operators and constructors, tailors, tentmakers, sailmakers, truck masters, vulcanizers, welders, and makers, repairers, and installers of magnetos, ignition systems, cameras, watches and clocks, instruments, and typewriters.

♣ ♣ ♣

Aero Squadron Organization in U. S. Army

While the Signal Corps is not giving out the exact organization of the Aero Squadron, the Army and Navy Journal publishes a tentative scheme, which outlines in a general way, the composition and organization of an Aero Squadron.

The squadron consists of Headquarters, Flying, Supply and Engineer divisions. Its officers are a major, captain and fourteen lieutenants, and an enlisted personnel of approximately 140 men.

The major is the commanding officer of the squadron, and it is not necessary that he should be a flier. He has an aid in the Headquarters Division, a lieutenant, who is in charge of all paper work, and who, in the absence of the major, takes command. The captain is in immediate command of the Flying Division, consisting of eleven lieutenants. He should be an expert flier and have a thorough knowledge of motors, planes and air currents. He designates the fliers for special duties and is responsible to the major for the planes.

The Supply Division is in charge of a lieutenant, who must not only look after all supplies for the squadron, but must attend to the transportation. Under the lieutenant in charge of supplies there is a mess officer. The Engineer Division officers must be experts in repair of planes, cars, trucks and cycles. They must keep a report sheet of all men under them, and a memorandum of parts needed to replace stock used. The enlisted force is made up of a sergeant major, a first sergeant, photographer, chauffeur, three corporals, besides dispatch carriers, a motor truck driver and two privates. The supply section has two clerks, a truckmaster, his assistants, a mess sergeant, supply sergeant, mechanic, a corporal, cooks, ten privates (first class, and privates) for general work. The enlisted men of the Engineering Section are four master signal electricians, four mechanicians (sergeants, first class) and five sergeants (second class), three corporals and three privates (first class). In the Flying Section of the squadron are one mechanician (sergeant, first class), one mechanician (sergeant, second class) for each two planes,

six corporals (one for each two planes), twelve corporals (drivers of motor trucks) and four privates (second class).

It is probable that there may be one or two more lieutenants than the number mentioned—at least one in the Engineer Division and perhaps two instead of one in the Supply Division. The full number of privates is not given. In addition to the planes there are motor trucks, an automobile for the headquarters, motor cycles, repair trucks, developing room for photographs, apparatus for signaling and other vehicles and devices.

A motor car distributor of Chicago has arranged to sell aircraft as well as road craft. He is the first motor car dealer to handle aircraft on a commercial basis.

Cotton Approved For Wings

Official denial that the government has been placing orders for silk for use in the manufacture of airplane wings has been issued by the Aircraft Production Board. Rumors that heavy purchases of silk were contemplated have been circulated and many offers have come to the purchasing department from manufacturers whose material was said to be satisfactory for airplane purposes.

It is true, however, that silk has been considered. In fact, all fabrics have been experimented with, and the Bureau of Standards has been working under the supervision of the Aircraft Production Board, endeavoring to find the best material for wings. In addition many experiments are being made by private individuals and manufacturers.

Out of all the fabrics placed under these tests cotton proved to be the most satisfactory. A new way of spinning this material was devised and this method is closely guarded as a valuable military secret. Roughly compared with the usual process of cloth production, its description is covevered by the term "spinning backward."

This new process cotton is said to surpass the stoutest linen and has passed the most rigid tests. Early experimenters thought it had an admixture of linen, but when unraveled it was found to be "pure cotton." It is understood the fabric has worked out so satisfactorily that the British Government has ordered several million yards for airplane purposes. It has also been found to be desirable for tentage.

New Type of Coupling

A newly designed coupling, adaptable to all magnetos, generator or pump shaft drives, is similar in construction to the Oldham type, excepting that it has an automatic spring takeup for wear and to prevent noise.

The center piece consists of a ring two inches with 3/32" wall; riveted solidly to the inside of this ring are two triangular shaped steel blocks. These rivets do not carry any load.

Placed midway between the two solid blocks are two similarly shaped blocks, loosely riveted and impelled inwardly by means of small coil springs. Regularly constructed shaft end members, each with two projections or jaws opposite each other, are inserted between the blocks, thus forcing the loose blocks outwardly from their inner rivet heads by deflecting the springs.

Due to spring pressure, these loose blocks hug the jaws at all times and will take up any wear. This squeezing action of the loose blocks does away of course with all looseness, rattle and back lash. The drive is meant to be taken on the solid blocks, but the spring tension is such that the loose blocks withstand a pressure of 34 pounds before they will squeeze outwardly.

About twenty-five of the largest motor car, truck and motor manufacturers have been testing this coupling for several months with satisfactory results in every case. Allowance is made for 1/32" wear, but tests covering from 25,000 to 30,000 miles have shown a wear of less than .005.

In the month of January, says an official statement issued by the British War Office on March 4th, the Germans dropped 1,482 bombs in the area occupied by British troops in France. In the same period British aviators dropped 7,653 bombs in enemy areas.

The Germans dropped only 221 bombs in the daytime, the statement adds, while the British dropped 5,000 between sunrise and sunset.

The Air Board of Great Britain is issuing instructions to manufacturers of aircraft regarding efficient methods of cutting aircraft lumber. Diagrams are circularized showing the correct way of sawing up planks of various grains.

That the terrible Turk, ally of the Hun, is using modern warfare methods under his master's tuition, is indicated in this view of the operation of the combined field buzzer and telephone

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XIII.

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE—This is the thirteenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

RECEIVING APPARATUS

PROBLEMS OF THE RECEIVER

(1) When a wireless aerial is set into oscillation, there is radiated into space a wave motion termed, **electric or electromagnetic waves.**

(2) These waves are composed of magnetic and static lines of force which are propagated at the rate of 186,000 miles per second (or 300,000,000 meters per second).

(3) The aerial at the **receiving station** is acted upon by both the electrostatic and electromagnetic fields, which cause the antenna system to oscillate at the same frequency as the transmitter.

(4) In order that the received energy may reach its maximum value the transmitter and receiver aerials must be carefully tuned to resonance, that is, they must possess the same natural frequency of oscillation.

(5) Resonance between the transmitter and receiver aerials is established when $L \times C = L^1 \times C^1$,

where L = the total inductance of the transmitter aerial;
C = the total capacity of the transmitter aerial;
L^1 = the total inductance of the receiving aerial;
C^1 = the total capacity of the receiving aerial.

No matter how large or how small the values of L, C, L^1, C^1, so long as $L \times C = L^1 \times C^1$, the two systems oscillate in **electrical resonance.**

(6) Aerials having the same natural frequency of oscillation obviously if set into excitation would radiate waves of the same length. This is simply another way of stating the fact that the receiving aerial is accurately tuned to the transmitter when, if set into oscillation, it radiates a wave of the same length as the transmitter aerial.

(7) The condition is rarely encountered in practice where $L \times C$ for the transmitter aerial $= L^1 \times C^1$ for the receiver aerial. That is, these aerials rarely possess the same physical dimensions or the same values of distributed inductance and distributed capacity.

(8) Because of this dissimilarity, the circuit of the receiving aerial must contain **tuning appliances** so that its natural frequency of oscillation can be made equal to that of the transmitter.

(9) These tuning devices are known as:

(1) the aerial tuning inductance;
(2) the short wave condenser.

Both are connected in series with the circuit from the aerial to the earth.

(10) From the simple equation for the natural wave length of an oscillation circuit, $\lambda = 59.6 \sqrt{L, C}$, it is easily seen that an **increase of L or C will increase the natural wave length, or a decrease of L or C will decrease the natural wave length.**

(11) By connecting a coil of wire in series with the antenna system at the base, its natural wave length is increased, and hence, as a receiving aerial it will **respond to long waves.** On the other hand, a series condenser connected in series with the receiving aerial reduces its capacity and therefore, as a receiving aerial it will respond to waves below the fundamental wave length.

(12) When the receiving operator tunes the receiving apparatus to a given transmitter, either by variation of inductance or capacity, he obtains the condition where **the reactance of the antenna circuit to the incoming signals is zero.** That is, the reactance of the **inductance** equals the reactance of the **capacity** for a given impressed frequency. Hence, the amplitude of the current flowing in the receiver circuit is governed by the impressed E. M. F. and the ohmic resistance (including other losses in the circuit).

PHENOMENA OF THE TELEPHONE RECEIVER

(1) **Vibrations in excess of 20,000 per second are practically inaudible to the human ear.**

(2) If a 10,000 cycle current flows through the windings of a magnetic telephone, the diaphragm will vibrate 20,000 times per second. These vibrations are inaudible to the average ear. If the frequency of the impressed E. M. F. is reduced, the vibrations of the telephone diaphragm become more and more audible, the maximum sound being secured (for a given E. M. F.) at frequencies near to **500 cycles per second.**

(3) The telephone diaphragm vibrates with the greatest amplitude when the **frequency of the impressed E. M. F. equals the mechanical frequency of the diaphragm.** That is, if the telephone diaphragm is deflected, and released, it will oscillate at a frequency determined by its mass and elasticity. Obviously, the greatest sound, as just remarked, will be produced when the frequency of the currents equals the natural frequency of the diaphragm. For the average receiver, the natural frequency of oscillation is around 1,000 vibrations per second.

(4) Currents above 10,000 cycles per second are inaudible, but those below this value become increasingly audible. Hence, an **audio frequency current is one whose frequency is less than 10,000 cycles per second. A radio frequency current is one whose frequency exceeds 10,000 cycles per second.**

(5) The frequencies employed in commercial wireless communication range from say 18,000 to 1,000,000 cycles per second, and since the ear will not respond to a rate of vibration so high as this, it is clear that we must supply some device at the receiving station which will change the incoming radio frequency current to an audio frequency current.

(6) Devices which effect this conversion are termed **oscillation detectors.**

(7) Among the simplest of oscillation detectors are, the solid rectifiers such as **cerusite, carborundum, galena, silicon, molybdenite,** etc.

(8) Possessing the **property of rectification,** these elements will convert a **radio frequency current** into a **uni-directional pulsating current.**

COUPLED RECEIVING SYSTEMS

(1) As in the transmitting apparatus, **coupled circuits** are generally employed in connection with the receiving apparatus; that is, rather than connect the oscillation detector in series with the antenna, it is placed in a special closed circuit in inductive relation to the antenna system.

(2) The detector circuit may be coupled to the antenna system,
- **(1) inductively,**
- **(2) conductively,**
- **(3) electrostatically (inductive or conductive).**

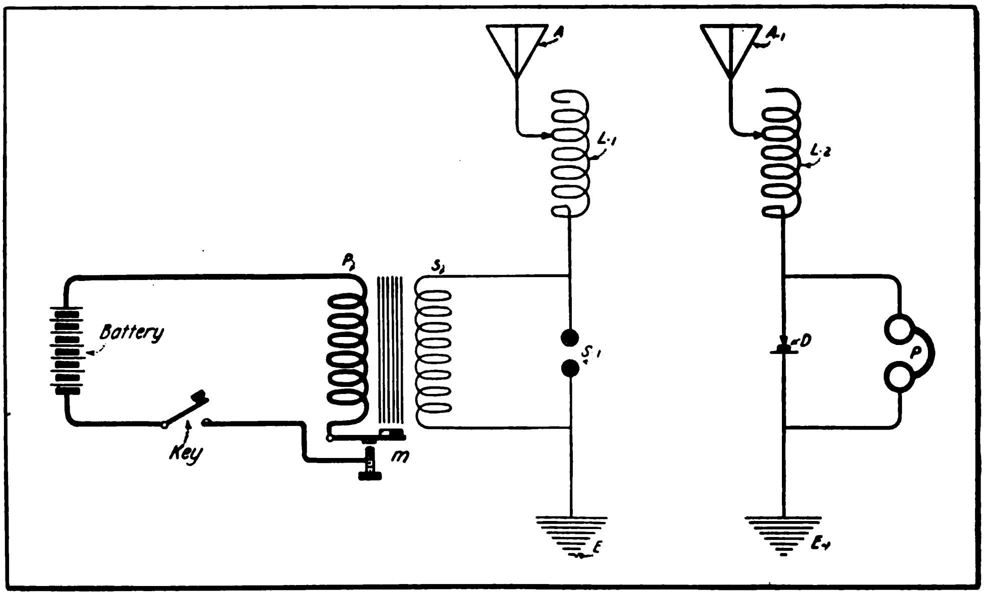


Figure 118

OBJECT OF THE DIAGRAM

To show the circuits of the so-called "plain aerial" transmitting and receiving system.

PRINCIPLE

An aerial wire (or group of wires) or any elevated capacity (preferably connected to earth at one end) possesses a certain value of distributed inductance and distributed capacity. If excited by a transient electrical charge, the aerial circuit will oscillate at a radio frequency determined by the magnitude of the inductance and capacity.

These oscillations set into motion groups of electrical waves which induce similar groups of oscillations in the receiving aerial.

The oscillations induced in the receiver circuits are of the same frequency as those of the transmitter. Direct response cannot be obtained in the head telephone, for reasons already explained. But if a rectifier be connected in series with the receiving aerial system, the incoming radio frequency currents are converted to direct current pulses which occur in groups following the spark of the transmitter. Each group impulses the telephone diaphragm once. The note of the spark discharge at the transmitting station is therefore reproduced in the receiver.

DESCRIPTION OF THE DIAGRAM

The antenna system at the transmitting station comprises the aerial wires A, the loading inductance or antenna coil L-1, the spark gap S-1, and the earth connection E. Across the spark gap is connected the secondary winding of the induction coil S which has a primary winding P with the magnetic interrupter M.

The receiving station comprises the aerial wires A', the loading inductance or antenna coil, L-2, the rectifier D, the shunt telephone P, and the earth connection E',

OPERATION

When the induction coil is placed into operation, the aerial is charged periodically at a rate determined by the frequency of the interrupter. For each charge given the antenna system, a spark discharges across the gap S-1 during the life of which a series of radio frequency oscillations flow in the complete antenna system. These radiate into space **electromagnetic** and **electrostatic fields**, which **charge and cut through** the receiving aerial wires A', inducing therein oscillations of similar frequency. By tuning the complete aerial system A' through the loading coil L-2, the currents in the receiving system will be built up to their maximum amplitude. Owing to the one way conductivity of the rectifier D, a series of direct current pulses flow through the telephone P, that is, each spark in the transmitter will send a decaying E. M. F. through the telephone which will produce one "click."

SPECIAL REMARKS

(1) If aerials A and A' have the same electrical dimensions, coils L-1 and L-2 are not required to establish resonance (provided all other conditions are equal). But if, for example, aerial A' is considerably shorter than aerial A, turns must be added at L-2 to establish resonance with the transmitting station.

(2) Similarly, the length of the wave radiated by the transmitting station, can be increased or decreased by the inductance L-1, that is, if turns are added at L-1, the antenna will radiate a long wave, and if they are taken out, the antenna will radiate a wave determined by its distributed inductance and capacity.

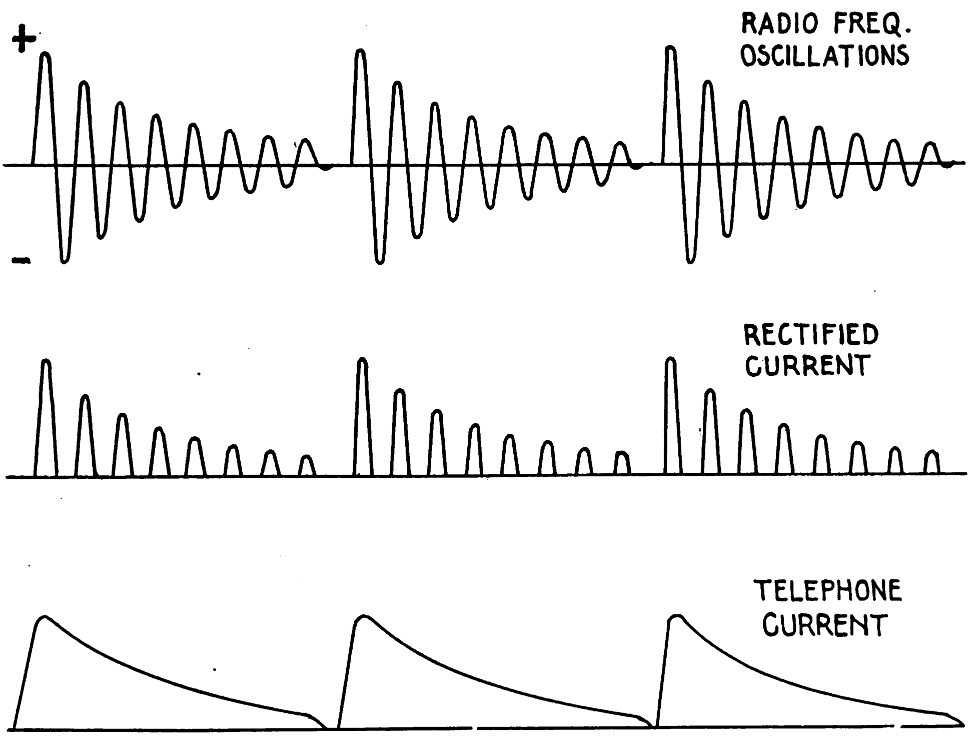


Figure 119.—Showing graphically how incoming radio frequency oscillations at the receiving station are converted into direct current pulses which actuate the telephone diaphragm. The oscillations on the upper line indicate those incoming at a given receiving station. Three groups are shown. A 500 cycle synchronous spark transmitter, for example, would induce in the receiving system 1,000 such groups. Their frequency is too great for response in the telephone, but when a rectifier is connected in the receiving circuit, one-half of each cycle is practically suppressed and the circuit is traversed by pulsating direct current as shown on the middle line. The frequency of the individual pulses is too great to obtain audible response from the telephone diaphragm, which responds to an average effect as shown by the lower line. Thus, 1,000 sparks at the transmitter will impulse the telephone diaphragm 1,000 times.

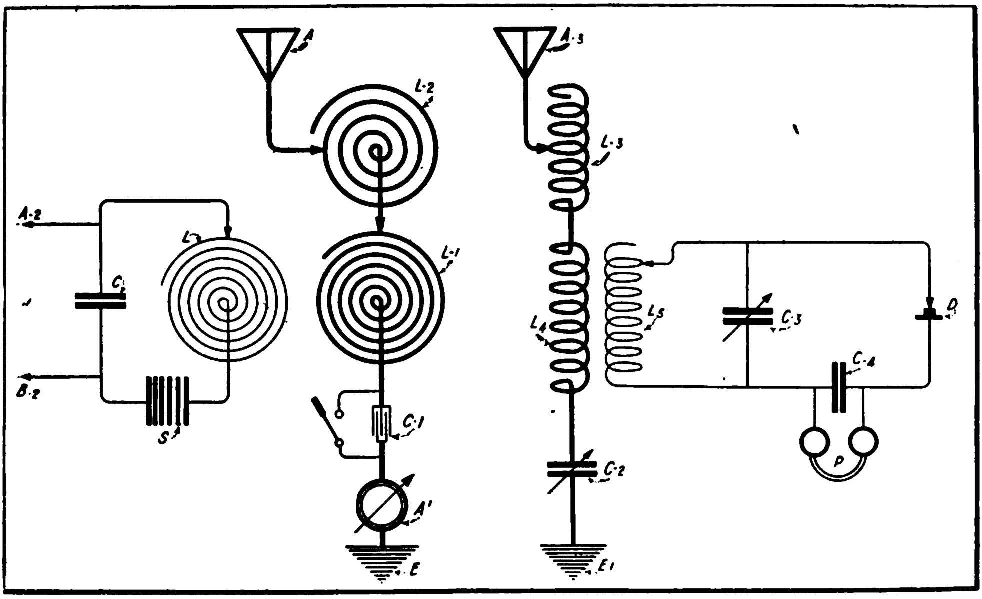


Figure 120

OBJECT OF THE DIAGRAM

To show the complete radio frequency circuits of an inductively coupled transmitting and receiving system, i. e., a diagram representative of modern apparatus for the production of damped oscillations.

PRINCIPLE

Powerful oscillations may be generated in a closed oscillation circuit from which energy can be transferred to the aerial wires by inductive coupling. Greater selectivity is obtainable at the receiving apparatus with inductive coupling because the character of the radiated wave can thus be closely governed. Similarly, the provision of inductive coupling at the receiver permits the operator to discriminate between stations, that is, to prevent interference.

DESCRIPTION OF THE DRAWING

The closed oscillation circuit of the transmitter is indicated by condenser C, inductance L, and spark gap S; and the open circuit by the aerial wires A, the antenna loading inductance L-2, the secondary winding of the oscillation transformer L-1, the short wave series condenser C-1, the aerial ammeter A^1, and the earth connection E. Connections A_2, B_2, extend to the secondary coil of a high voltage transformer, one giving from 15,000 to 20,000 volts.

The **receiving system** is represented by the **aerial wires** A_3, the **antenna loading inductance** L-3, the **primary winding of the receiving transformer** L-4, the **short wave variable condenser** C-2, and the **earth connection** E^1. The secondary or closed circuit of the receiving system comprises the tuning coil L-5, the shunt **condenser C-3, the telephone condenser** C-4, the **crystal rectifier** D, and the **head telephone P.**

OPERATION

If the closed and open circuits at the transmitter are carefully tuned to the same natural frequency of oscillation, and moreover, if the coupling is adjusted so that the antenna system radiates a pure wave*, the conditions of a modern transmitter are fully satisfied.

Oscillations flowing in the circuit of the aerial wires A, radiate electromagnetic waves which act inductively upon the receiving wires A^1.

Radio frequency oscillations flow through coil L-4 setting up a magnetic field which acts inductively upon the coil L-5. The circuit L-5, C-3, is tuned to the given frequency of the incoming oscillations by the shunt condenser C-3. Condenser C-3, may, however, be eliminated, the requisite shunt capacity being found in the turns of the coil.

The oscillations in the secondary system are rectified by the crystal D, and a series of direct current pulses charge the condenser C-4. C-4 discharges through the head telephone P in one direction creating a single sound for each group.

SPECIAL REMARKS

(1) The diagram of figure 120 indicates the fundamental circuits of Marconi's famous four circuit tuning patent.

(2) The closed and open oscillation circuits of the transmitter are carefully tuned to electrical resonance. Resonance adjustments may be found by a hot wire ammeter shown at A^1. The circuits may be tuned to a definite wave length by means of a wavemeter. Similarly, the open and closed circuits of the receiving apparatus must be tuned to the frequency of the transmitter, that is, circuits A^1, L-3, L-4, C-2, E, must be tuned to circuit L-5, C-3.

(3) The tuning appliances shown in the diagram of figure 120 are in general all that are required in modern wireless systems employing damped oscillations.

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*A single wave of decrement less than 0.2 per complete cycle.

A Digest of Electrical Progress

Automatic Headlight-Dimmer for Automobiles—The Problems of Iron Wire Transmission—Checking Up Synchroscopes for the Paralleling of Alternators—A Mercury Vapor Pump for the Production of High Vacuum—The Regulation of a Series Single-Phase Motor.

Automatic Headlight-Dimmer for Automobiles

IT has been customary for automobile drivers, as a matter of courtesy, to dim their headlights as they pass another automobile. In territories otherwise unlighted, this is a wise precaution. Now, through a recent invention of Victor Olson, the automobile operator is saved the trouble of shifting his headlights from bright to dim, leaving him free to tend to the driving mechanism of the automobile.

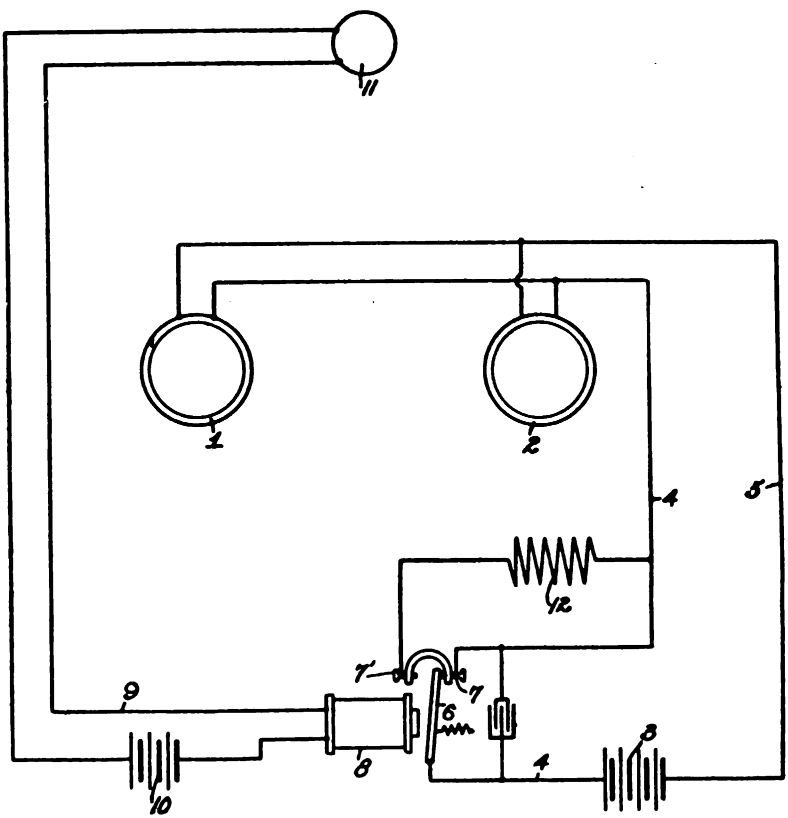


Figure 1—Circuit for Automatic Headlight-Dimmer for Automobiles

The invention is made operative immediately the rays of a distant automobile are played upon the headlights of an auto approaching in the opposite direction, a selenium cell being acted upon which closes a magnetic relay in the automobile and automatically dims the light until the automobile coming in the opposite direction has passed.

The circuits of this system are shown in figure 1, where the headlights of an automobile are indicated at 1 and 2, a small relay at 8, with the lever 6 and the contact point 7; a shunt condenser at 4, the local battery at 3, and a dimming resistance at 12. The selenium cell is indicated at 11, its battery at 10, which is in series with the relay 8.

When the light rays of a distant automobile fall upon the selenium cell 11, its resistance drops, energizing the magnet 8, and drawing over the lever 6. This throws resistance 12 in series with the headlight circuit, dimming the lights.

The Problems of Iron Wire Transmission

THERE was published in the September, 1917, issue of this magazine a report of investigations made by L. W. W. Morrow, of the University of Oklahoma, concerning the use of iron wires for transmission of electric power. The writer was conservative in his general conclusions, but he remarked that conditions as to cost of copper, power to be transmitted, voltage, etc., would determine the advisability of using iron instead of copper wire, and also would determine the type of iron wire which should be used.

M. D. Leslie, in a recent issue of the Electrical World, describes two power transmission lines employing iron wire which originate in Dodge City, Kansas. One of these lines is 31 miles in length, extendng to Bucklin, Kansas. It consists of three No. 6 E. B. B. iron wires spaced four feet apart horizontally on Bates steel poles set 300 feet apart. The other line, which goes to Minneola, Kansas, is 22 miles long and consists of three No. 6 B. B. iron wires spaced triangularly 40 inches apart on Franklin steel poles set 375 feet apart. The first line has no transposition, but the second has three, 7, 14, and 21 miles from Dodge City. Both of these circuits operate at 22,000 volts.

An important factor observed was the high charging current of the line. The calculated charging current on the Minneola circuit was 13 amperes on the 2,300 volt side and 21 amperes on the Bucklin line, but in practice the ammeter indicated about 18 amperes per phase from the 2,300 volt side with very little change of variation of load (from the 31-mile line). When the 22-mile line was added, this was run up to about 33 amperes per phase, but was later reduced by the installation of two 15 kva. transformers near Dodge City on the 31-mile line. The transformers are seldom loaded and furnish some lagging current. The current on the two wires is now about 30 amperes per phase. The writer remarks:

> It appears that the heavy current experienced produces a leading power factor, although it is possible that it is lagging, owing to the high reactance of the iron wire and the low power factor of the transformers under such light loads. The first indication that this current was leading was observed during Christmas week under severe overload conditions, when it was found that a higher voltage could be maintained in Dodge City with the Bucklin line connected than was possible without it.

In view of experience obtained with this circuit, the writer concludes that long, light-loaded iron wire transmission lines on steel poles require a heavy charging current in proportion to the load that they are supposed to carry. A distinct disadvantage enters into the case at this point because large capacity ammeters, automatic switches and transformers are required for a relatively small load. This may prove expensive. In addition, it is a disadvantage to the line that it operates at a high line loss irrespective of the load that is carried.

The writer summarizes:

> Apparently more inductive load at the delivery end of line would improve the situation. It would be necessary for this load to be on the line continuously, but this does not appear to be practicable.

One thing is certain, and that is that the suitability of iron wire for transmission purposes where light loads are to be carried considerable distances is dependent on the charging current and not on the load current to be carried. This statement should not be taken as a serious argument against iron wire in a general way, but as one of the difficulties encountered. In the operation of these lines it has been found that they return a fair average rate on the investment. None of the lines built or contemplated would pay if copper wire were used at the present prices.

Checking Up Synchroscopes for the Paralleling of Alternators

HOW to check up and put into operation a synchroscope is interestingly described in an article by C. Otto Von Dannenberg in a recent issue of the Electrical World. A diagram representative of conditions usually encountered in practice and which indicates only the necessary connections is shown in figure 2.

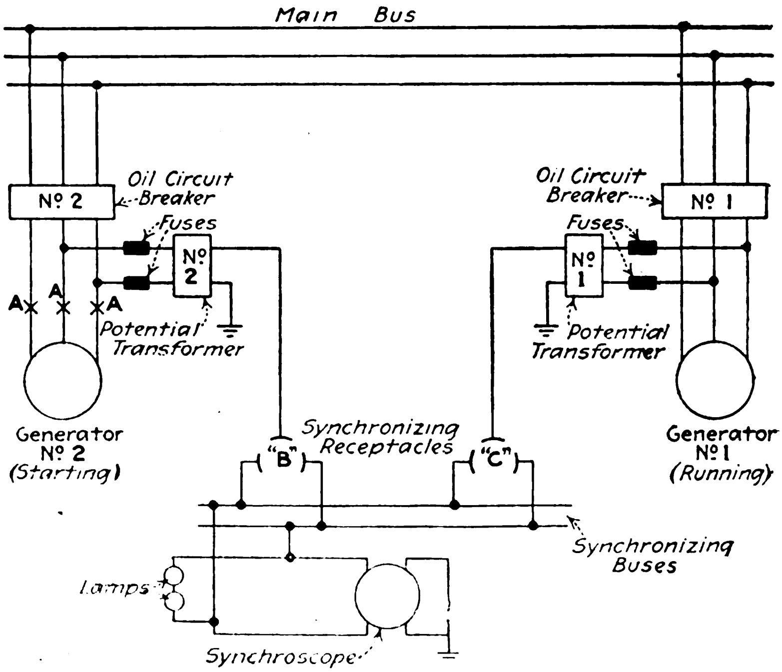


Figure 2—Diagram of connections for checking up synchroscopes in the paralleling of alternators

In this diagram, it is assumed that two three-phase generators are about to be connected in parallel and that the phase rotation has been found by test to be correct. The generated voltage is assumed to be of such value as to require the use of potential transformers to step down to the operating voltage of the synchroscope.

By way of preliminary explanation, the writer remarks:

With the connections as indicated and the "machine starting" and "machine running" plugs inserted in receptacles B and C, respectively, it might be assumed in general that the oil circuit breaker of the "starting machine," generator No. 2, could be closed when the lamps were dark and the synchroscope pointer was at rest just over the mark at the upper part of top of its scale. This would be in accordance with the general method in use in the United States. It so happens, however, that it is not

an unusual or exceptional occurrence to find potential transformers, even of the same make, with terminals wrongly marked for polarity or leads wrongly brought out of the case, so that the connections of the different transformers would not be symmetrical. This condition would give crossed connections which would cause the lamps to be bright at synchronism and the synchroscope pointer to take a position exactly 180 degrees from its correct location, so that closing breaker No. 2 with the lamps dark and the pointer at the top of the scale might cause serious damage to either or both generators, or at least a considerable disturbance on the system, since it is seldom, except in the smallest stations, that one finds generator breakers set for automatic operation.

A difficulty of such nature may be obviated with positive assurance of the correct connection by first disconnecting the leads of generator No. 2 at the terminal board, or at a point such as A, and then closing the oil circuit breaker No. 2. The conditions then existing will be the same as at synchronism, and the lamps will either glow brightly or darkly and the synchroscope pointer will assume either an upper or a lower position.

Should the pointer come to rest in the lower position with the lamps bright and it is desired that they be dark, the leads of the potential transformer of generator No. 2 should be reversed; if, however, the lamps are required to burn brightly at synchronism, the pointer of the synchroscope may be loosened on its shaft and shifted to its upper position. The switch of generator No. 2 may now be opened, the leads reconnected and the machine put in service.

The writer remarks, that while lamps nowadays are seldom used as a permanent synchronizing arrangement, they are usually an adjunct to a synchroscope, and the method described applies obviously as well when lamps alone are used for this purpose.

A Mercury Vapor Pump for the Production of High Vacuum

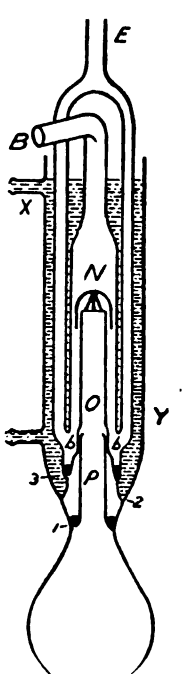


Figure 3—Diagram of high vacuum mercury vapor pump

The molecular pump of Gaede has given stimulus to the design of several high-vacuum pumps. In a past issue of the "Physical Review," Charles T. Knipp has described a pump made wholly of glass which, he believes, possesses improvements over those heretofore produced. Diagrammatically the pump is shown in figure 3. The tube E is attached to the rough pump while the bulb to be exhausted and trap are fused to B. The mercury vapor rises from the lower bulb, which is heated in a sand or heavy oil bath, streams up through the short tubes P and O and is deflected downward through an annular throat by an umbrella N. The mercury vapor at once condenses on the water-cooled surface of the enveloping tube, and the gas that comes from B is forced mechanically downward from the lower edge of N along the cooled surface of the condensing chamber. The gas thus accumulated flows through the lateral tubes bb, which unite at the top and form the exhaust tube E. These are enveloped by the water jacket XY. This design tends to keep the mercury, which collects at the ring-seal 3, cool, and thus removes the objection that mercury vapor having an upward velocity would enter the annular condensing chamber. To prevent the hot mercury vapor streaming up from the boiler from con-

densing on the surfaces at 3, the short tube P is inserted to act on the shield. The upper end of P telescopes loosely into the lower end of O, while the lower end is secured by the ring-seal 1, having also a small valve opening in it through which the mercury passes back into the boiler.

If the upper end of P is conical, condensed mercury vapor is caught in the annular space formed and automatically seals the space PO from the cavity just outside of P. This construction simplifies the problem of the glass-blower, since the tube throughout the process is kept symmetrical.

The Regulation of a Series Single-Phase Motor

A WRITER in the Electrical Review has described a method whereby a series single-phase alternating commutator motor will maintain a constant speed similar to a direct current shunt motor while running.

The connections are shown in figure 4. A, is the motor armature, F, the field winding, R, a resistance capable of carrying 1/10 normal full load line amperes, R_0 is a resistance capable of carrying continuously full load current.

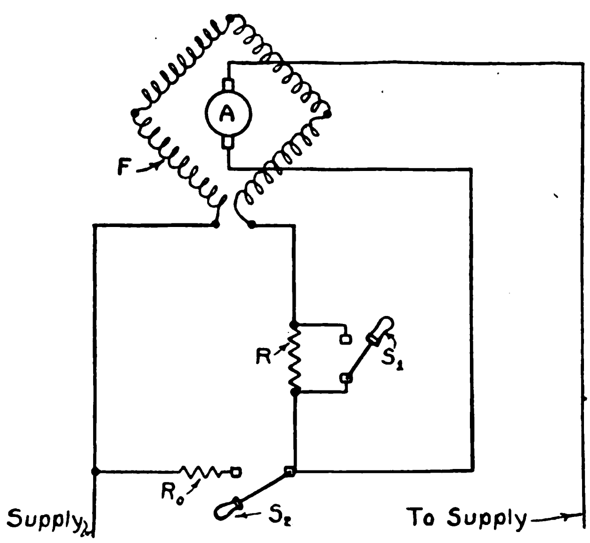


Figure 4—Diagram of connections to secure constant speed in a series single-phase motor

The operation is as follows: To start the motor close the switch S_1, and open switch S_2. Then connect the motor supply circuit. After starting, close the switch S_2 and open switch S_1 simultaneously. This operation can be much simplified by a specially constructed controller switch. The resistance R should be of such relative value to R_0 as to cause seven to ten per cent. of normal full load field excitation in the motor field. Resistance R should be so proportioned as to allow the armature to take full load current and will be approximately equal to the series field resistance.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A Compact and Efficient Rotary Spark Gap

OF the many new wireless telegraph instruments introduced within the last decade, very few, with the exception of the amplifying detector, have played such an important role as the rotary spark gap. Since its general adoption some five or six years ago this instrument has been growing in favor, until to-day it is employed in the majority of successful stations.

Although developed to a high state of efficiency as regards operation, the rotary gap of to-day still retains most of the earmarks of the old-fashioned design incorporated in the pioneer gaps of this type. This statement does not of course apply in the case of enclosed and quenched gaps combined in the construction of certain rotary gaps of the present.

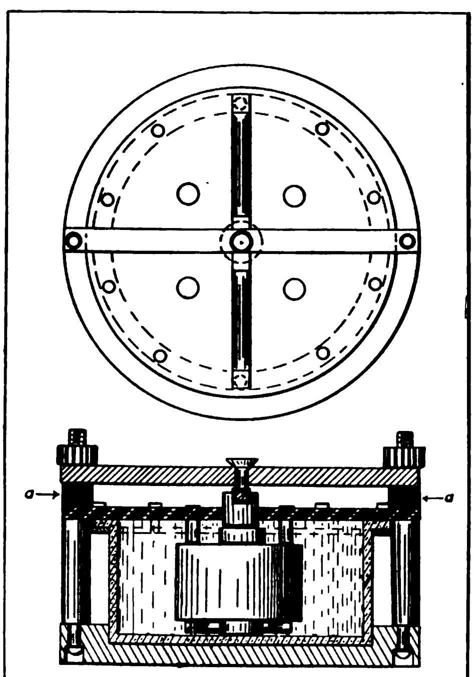


Figure 1— First Prize Article

In order to develop a rotary gap which will embody the stability of design which is displayed by most of the other instruments used in connection with wireless telegraphy, it will be found necessary to depart somewhat from the usual line adhered to. Perhaps the easiest way in which to introduce a radical change in the general outline of any instrument is to change its principal axis of operation from vertical to horizontal, or vice versa. This the writer has done in an attempt to originate a rotary spark gap of sturdy design.

It will be noted from the accompanying drawings that particular attention has been paid to obtain the best mechanical and electrical construction possible, with the least expenditure of money and time. The gap is suitable for any range of power up to about ½ kw.

The novel features claimed are: the manner in which the motor is mounted and attached to the rotating member, through a flexible coupling; the use of several small phonograph records to form a heavy insulating member for the vital part of the gap; and the manner in which the various parts of the instrument are held together and adjusted, permitting very accurate construction.

From the partial cross-sectional elevation, figure 1, it will be noted that

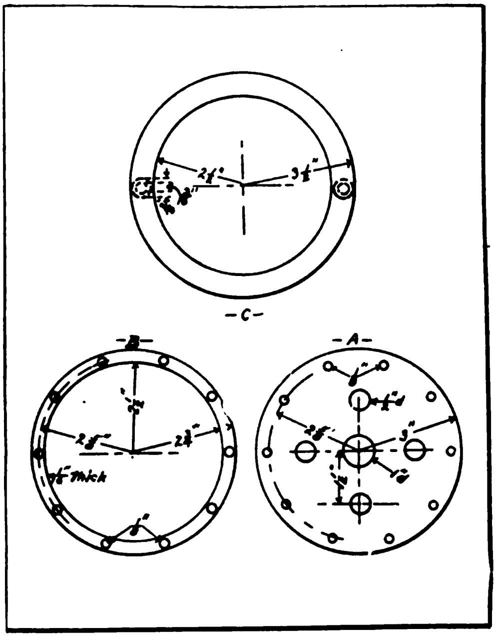


Figure 2—First Prize Article

the motor is enclosed in a round glass case which fits into a hollow space in the round wooden base. The case is held in position by the pressure exerted upon the composition top, through the soft rubber cushions, *a-a* which in turn form a part of the round fibre uprights which connect the ends of the top brass cross-rod and the wooden base.

The motor is hung from a composition top made up of several small disk records such as are sold for ten cents each. The small bolts which clamp these together near the periphery also secure this top to the glass case by means of the thin brass ring held in position by the glass shoulder around the top of the case. In this manner the bolts, which are to act as sparking points, must always remain in line because of their connection with the glass shoulder which will not warp. In connecting the gap for use, one wire is run to this ring and the other to one of the bolts passing through the fibre supports.

The rubber cushions mentioned make it possible to adjust the length of the gap by simply turning the insulated nuts on the top of the brass bearing rod, the rubber providing sufficient spring to prevent the nuts from becoming loose through vibration.

Having studied the gap from the standpoint of general composition and operation, the actual construction of the various parts which enter into its make-up can now be dealt with more fully.

The first requisite is a round glass jar about 5 inches in diameter and from 2½ to 3 inches deep, with a narrow shoulder located near the top. A heavy glass butter jar of this size should be readily obtainable. A jar with slanting sides can be used if the round style is hard to find, provided the slant is outward at the top.

Having obtained a glass jar of the proper size it is only necessary to file a few small nicks at various points around the top, for the admission of air to cool the motor; and one large indentation about 3/16 of an inch deep, to be used as an exit for the motor wires. This completes the work on the jar.

A small electric motor of about 1/40 h.p. suitable for running in a vertical position is sufficient for any size of gap up to about ½ kw. capacity. This motor should be capable of being mounted by means of the bolts which hold the field pieces together somewhat after the manner shown in figure 1.

Three or four disk phonograph records are needed to form the top, which can be clamped together and drilled with several holes to be placed in positions similar to those at A, figure 2. These records should be large enough to overlap the top edge of the glass jar on all sides by about ½ inch in case the dimensions given are not closely followed.

A brass ring should now be made after the pattern of the one shown at B, figure 2. The holes in this are, of course, intended to coincide with those near the circumference of the disks, which are to form the top. A metal ring of the type desired can be made from brass stripping wound edgewise, or better, may be cut from a solid piece of sheet brass.

A plan view of the base is shown at

C, figure 2. This is best made of mahogany. No separate elevation or cross-sectional view is given, as the general idea can be obtained from figure 1.

The rotating member, its shaft, and the metal support for the same are pictured in figure 3 at C, B, and A, respectively. From this drawing it is patent that the rotating member is nothing more or less than brass rod, square in cross-section at the center and ends, and filed to a semi-streamline form at all other points. This rod is supported in the center by a short, flat-headed steel bolt, which is tightly screwed into threads made in the rod, and riveted in place to prevent its coming loose. This is done with the bolt in place in the hole in the brass supports, A.

A few small steel balls are fitted between the short shaft and the wall of the enlarged hole at the top of the brass support, in the center. These take care of the strain and wear due to the weight of the rotating member, while the lower part of the hole acts as a guide to prevent the shaft from rocking, at the same time providing a good electrical connection to the rotating spark arm. No oil is used in this bearing.

Two round fibre supports or uprights, with brass bolts and insulated nuts are required. These should be similar to the ones illustrated in figure 3 at D. These, in conjunction with two pieces of soft rubber—one of which is shown at E in the same sketch, and the brass cross-rod previously mentioned—serve to hold the gap together as already described.

Ten or more sparking points can be made from brass bolts, which may either be fitted with short round ends such as are used for switch points, or with ordinary brass nuts. These pieces are not shown except in figure 1, as their size and style may be varied considerably in any manner desired.

No special provision has been made for the binding posts, which can be attached for taking off leads in the manner previously mentioned. It will also be noted that no detailed sketch for the motor supports is in evidence.

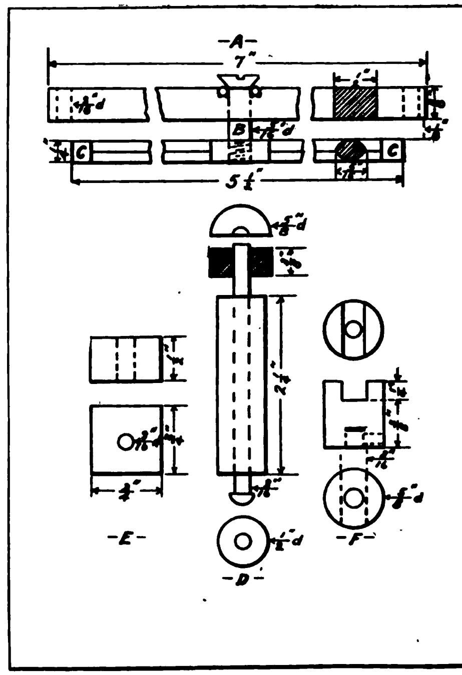


Figure 3—First Prize Article

These parts, as in the cases of the sparking points and binding posts, can be varied through such a wide range that no separate description is deemed necessary.

The various parts which have been described can now be assembled after the manner depicted in figure 1. The first step should be to bolt the motor to the several disks, after first securing to the long end of the shaft the fibre coupling shown in figure 3 at F. When this has been done the disks should be bolted to the ring near the top of the jar, using the spark point bolts, and after placing a round piece of felt in position for the jar to rest on, the latter can be set in place in the wooden base.

The completion of the instrument is now easily accomplished, and the adjusting of the gap a matter of personal supervision. The motor bearings can be oiled when necessary through the small holes in the composition top, through which the air to cool the motor is drawn by the rotating of the metal arm.

The cost of constructing a gap on the lines which have been laid out by the

writer should not exceed $6.00 for materials, including the motor. In appearance it will equal many expensive instruments of lower efficiency.

In order to completely enclose this form of rotary gap it is only necessary to place a large inverted glass jar over the instrument and supply the lower edge with a felt ring to cut down the noise. This, however, decreases the heat radiation, and is not considered advisable.

The main attraction of a rotary spark gap of the type outlined lies in the compactness and high insulating qualities incorporated in the design submitted, and to those who appreciate symmetrical design this gap should appeal very strongly.

R. U. CLARK, 3RD, *Massachusetts.*

SECOND PRIZE, FIVE DOLLARS

A Home-Made Insulator for Aerials

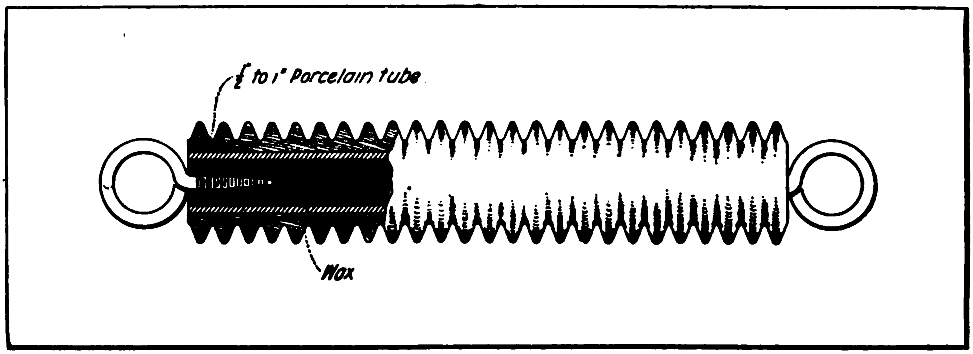


Figure 1—Second Prize Article

Because of the limited supply of tools and materials, the amateur finds it difficult to construct an efficient aerial insulator. High grade insulators such as may be purchased in the open market are too expensive to be considered.

I have had a disagreeable experience with imperfect insulators and therefore I decided to perfect an improved insulator for amateurs—one which the experimenter who hasn't a first-class workshop can easily construct.

The general method of construction follows:

Take the stick of an old mop or broom with a screw end. Saw off the handle from the screw as in figure 1. Keep the threaded part and bore or drill a hole large enough to permit the insertion of a 6 inch to 10 inch porcelain tube ½ inch to 1 inch in diameter (the ends of which are to be cut out if you buy tubes with ends). Next coat the inside wall of the bored hole with melted wax or glue. Insert the porcelain tube in the hollow. Pour melted paraffine or melted beeswax until full; then allow it to partially harden, but before it completely crystalizes, imbed therein two eye-screws, one to two inches in length, as shown in figure 1. Then lay aside until hard. Coat the spiral or corrugated insulator with a good grade of beeswax, and over this put one or two coats of waterproof paint. Asphaltum has been found excellent for this purpose. Further details of construction appear in the drawings. This insulator has the appearance of commercial insulators. The corrugations serve to reduce the surface leakage in damp weather. This is an important feature.

STEPHENS MURANDE, *New York.*

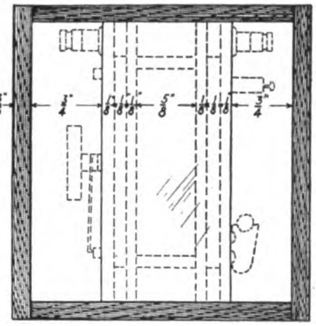


Figure 1

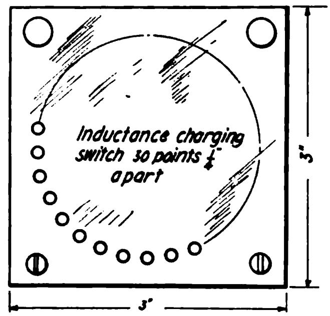


Figure 2

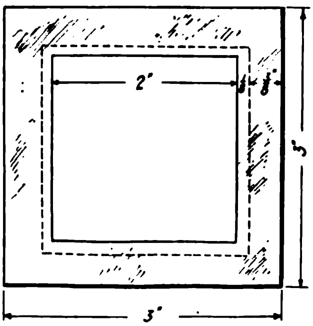


Figure 3

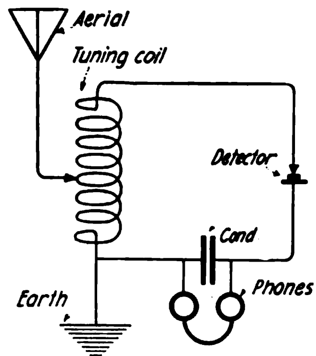


Figure 4

Third Prize Article

THIRD PRIZE

A Small Portable Receiving Set

In Signal Corps field work a small light receiving set is often required. The receiving set herewith described meets all requirements and will give response over fair distances.

The oscillation transformer, which, by the way, is a single tuning coil, is wound on the wooden form shown in figure 4. It has five hundred turns of No. 26 cotton-covered wire, with leads brought out every sixteenth turn. The switch for changing the primary inductance, figure 2, has thirty ⅛" x ⅛" contacts mounted on a bakelite panel ⅛" in thickness. This panel is fastened to small blocks of wood glued to each of the four corners of the frame on which the wire is wound. Binding posts can be located on two of the corners for the aerial and ground connections.

The condenser, which consists of ten sheets of tinfoil 2" x 2", separated by wax paper, is placed in the hole inside the tuning coil and the panel on which the detector is mounted is placed over it and screwed down. The complete assembly is shown in figure 1 and the diagram of connections in figure 4. It is to be noted that a fixed number of turns are used in the detector circuit, the tuning being effected by the antenna connection above.

The case can be made of any strong wood and the covers may be hinged so as to open, allowing the set to stand upright. A set of this kind was tried out at my station before the United States entered the war. Excellent results were obtained. With a loading coil and a standard size aerial it was possible to receive Arlington very clearly.

JOHN B. COLEMAN, *Pennsylvania.*

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

AN amateur recently remarked: "What have you that is new to present to amateur experimenters in event they are allowed to work their stations after the war?"

The tone of the remark indicates that the experimenter doubted that any progress had been made in the wireless art since the closing of his experimental station. If he knew of the new inventions that have developed since the beginning of the war! They are astounding.

Of course, war safety measures do not permit us to speak more in detail but let it be said emphatically that never will there be such a wealth of material available for experimenters' use than after the close of the European conflict.

Various types of receiving apparatus which the experimenter may imitate when he again is permitted to construct wireless telegraph equipment are described from month to month in the Radio Science department of this magazine. Members of the Association are earnestly advised to follow this section closely and to retain their copies for future use.

Radio telephony will, in the future, play an important part in amateur communication. A small-sized vacuum tube connected for the production of undamped oscillations will permit radio telephonic conversation to be carried on over distances of one to three miles, thereby opening up an entirely new field for the amateur experimenter in radio. Wireless telephone investigators have heretofore employed the arc system for generating the requisite radio frequency current; the expense of this construction was beyond the means of the experimenter. It is known now that a single vacuum tube works with greater efficiency and can probably be had at a much less initial expense. Also, it is simple to operate.

The use of open circuit oscillators in connection with vacuum tubes will amplify radio signals to a marked degree. These circuits, which have been described in the Radio Science Department of this magazine, are equally applicable to crystal rectifiers. Surprising results are in store for the experimenter who has not employed one of these circuits.

According to published newspaper reports there still remain throughout the country amateur experimenters who have taken down their aerials, but have failed to dismantle the trans-

(*Continued on page* 702.)

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of The Wireless Age, published monthly, at New York, N. Y., for April 1, 1918.

State of New York, County of New York, *ss.*

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared J. Andrew White, who, having been duly sworn according to law, deposes and says that he is the editor of The Wireless Age, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publishers, editor, managing editor, and business managers are:

Names of— Post Office Address—

Publishers..Wireless Press, Inc.,
25 Elm St., New York, N. Y.

Editor..J. Andrew White,
25 Elm St., New York, N. Y.

Managing Editor—None.

Business Manager—Alonzo Fogal, Jr.,
25 Elm St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

Wireless Press, Inc., 25 Elm St., New York, N. Y.
John Bottomley (851 shares), 233 Broadway, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

J. ANDREW WHITE,
Editor.

Sworn to and subscribed before me this 10th day of April, 1918.

(Seal) WILLIAM J. KINDGEN,
(My commission expires March 30, 1920.)
Bronx County, No. 29. Certificate filed in New York County, No. 198 Register, No. 10,159.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

J. M. B., New South Pittsburgh, inquires:

Ques.—(1) Please publish a diagram showing the connections of a regenerative receiver, employing a loose coupler, loading coil, grid condenser, and variable condenser for use with the three-element vacuum valve.

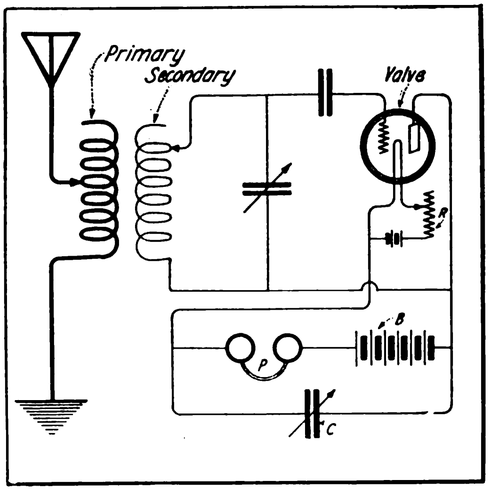


Figure 1

Ans.—(1) A simple diagram of connections is shown in figure 1, where the grid and plate circuits are electrostatically coupled through the coupling condenser shunted across the head telephone. Other diagrams of regenerative receivers appear in the textbook "Practical Wireless Telegraphy" and in the book, "How to Conduct a Radio Club" copies of which can be purchased from the Wireless Press, Inc., 25 Elm Street, New York City.

* * *

C. L. W., New York City, inquires:

Ques.—(1) If the leads from the primary and secondary of a long wave tuning transformer are five inches in length, would this have any effect upon the signals?

Ans.—(1) These leads would do no harm.

Ques.—(2) What range could I expect from a 1 kw. transformer coil in connection with a 110 volt 5 ampere D.C. generator, under favorable conditions?

Ans.—(2) We assume that you are referring to an induction coil to be operated with a magnetic or electrolytic interrupter. If so, you should be able to transmit 20 to 30 miles in daylight and from 200 to 600 miles after dark during the favorable months of the year. You are, of course, aware that experimenters are not permitted to operate or construct wireless apparatus during the period of the War.

Ques.—(3) Is there any circuit available at the present time for the reception of undamped waves which gives better results than the Armstrong regenerative circuit?

Ans.—(3) This circuit seems to fulfill all requirements for long distance telegraphy, but of course stronger signals can be obtained from a far distant station by means of a radio frequency amplifier; i.e., by connecting a number of valves in cascade for the amplification of radio frequencies.

Ques.—(4) What experience is necessary to get the best results from a single step multi-audio-fone, to get it in working order? I had one with everything connected properly, yet I could not obtain as loud signals with the audio-fone as without it.

Ans.—(4) We have never been able to secure the details of construction of this device, nor have we information concerning its circuits. Consequently, we can offer you no advice.

* * *

L. A. R., Seattle, Wash., inquires:

Ques.—(1) Where can I obtain a diagram showing how the vacuum valve is connected up for the production of radio frequency currents?

Ans.—(1) Such a diagram is shown on page 276 of the textbook, "Practical Wireless Telegraphy." The plate and grid circuits are shunted by inductance and capacity. They are usually magnetically or electrostatically coupled, so as to transfer energy from the plate circuit into the grid circuit. This keeps the valve in a state of oscillation.

Ques.—(2) What do you consider the most simple cascade amplification system for the amateur's use?

Ans.—(2) An audio frequency amplifier is perhaps the most satisfactory, simple iron core transformers being used in the plate circuit of each valve to transfer energy to the grid circuit of the next valve. The primary windings of these transformers may have inductance of 20 henries and the secondary from 75 to 100 henries. An iron core is generally used. The most efficient results and the greatest ease of operation are secured by cascade radio frequency amplification, that is, the plate and grid circuits of successive valves are coupled through a simple radio frequency transformer.

Ques.—(3) I have been told that great care must be used in the design of a receiving tuner to be employed in connection

WHERE TO BUY

with the vacuum valve, particularly in respect to the disposition of the various connecting leads.

Ans.—(3) At the least, the set should be designed so that change in any of the elements of the circuit will not change the capacity to earth of the various coils. For example, the free end of the secondary winding generally has the maximum potential, but if a device placed near to it does not remain in the same position it will change the tuning of the circuit. It is desirable in any receiving set that circuits which have no direct relation be placed at right angles to one another. In short, the usual precautions taken in the design of tuners suffice for the vacuum valve.

In order that the capacity effect of the body of the manipulator may not interfere with the tuning of the circuits, the entire receiving set can be covered by a gauze screen and connected to earth.

* * *

D. A. L., Washington, D. C.

Regenerative amplification circuits may be connected to a battery of vacuum valves in cascade, but sufficient amplification is obtained without the use of these transformers. However, when a single bulb is employed, some advantage is derived in employing regenerative couplings, particularly at radio frequencies.

* * *

H. P. H., Highland Park, Mich., inquires:

Ques.—(1) Referring to the description of a ½ kw. 500 cycle generator in the December issue of THE WIRELESS AGE, are the field coils wound for 110 volts D.C., and if so, about what current should it draw?

Ans.—(1) The field is wound for 110 volts D.C. and will take about ½ ampere.

Ques.—(2) In order to get the same results, what size wire and number of turns should be used for six to eight volts to be furnished by a generator?

Ans.—(2) You will see from the answer to query No. 1, that since the field winding contains 13,000 turns at ½ ampere there are 6,500 ampere turns. This is for the same density in the gap and the same pole face area. A good off-hand formula for determining the number of ampere turns in the field is: $AT = \frac{11 \times A \times B \times 2g}{30}$

where A = the area of the pole face;
B = the field density in the gap;
and g = the length of the air gap in inches.

Ques.—(3) The area of the pole faces in the above machine is 1.5 sq. in. If this is reduced to .625 sq. in. and the machine in general reduced in the same proportion except the air gap which is to be .006″ instead of .030″, is it safe to assume that the output will be slightly in excess of ¼ kw?

Ans.—(3) Off-hand, yes. In this connection we would state that a machine with a laminated structure and .006″ air gap would be an instrument of precision that could be put on exhibition.

Ques.—(4) What size wire should be employed in the armature coil in view of the fact that the output is to be reduced?

Ans.—(4) For a small machine at a frequency of 500 cycles allow 1,000 circular mils per ampere. If the machine is to generate 3.5 amperes, 3,500 circular mils will be required. No. 14 double cotton covered wire (4,106 circular mils) should be employed. The use of stranded wire is advised.

Ques.—(5) Should the number of layers and turns per layer be the same as the ½ kw. generator in order to get the same voltage?

Ans.—(5) If the area of the pole is reduced more turns will be required on the stator pole for the same voltage.

Ques.—(6) About what per cent will a cast iron rotor decrease the efficiency?

Ans.—(6) It is difficult to state offhand; in fact, the use of cast iron is not recommended.

Ques.—(7) I failed to state that I am increasing the poles from 9 to 10, mainly to facilitate measuring the diameter while grinding and turning. I intend to run the machine at 3,000 r.p.m.

Ans.—(7) You should take into consideration that the condensive reactance of the condenser, the reactance of the transformer primary and secondary, and the reactance of the generator are closely connected in radio design, and any change in one of the units calls for a corresponding compensation in either or both of the other units. Moreover, this state of affairs may call for a fourth change, namely, a reactance coil. This has been pointed out by Mr. H. E. Hallborg in the proceedings of the Institute of Radio Engineers, and by many writers in other publications.

* * *

H. M., Kiel, Wis.:

The diagram of connections for the beat receiver given in the book "How to Conduct a Radio Club" will inform you how to wire up the apparatus described, shown on page 347 of the February, 1917, issue of THE WIRELESS AGE. With the information given therein and that published in previous issues of THE WIRELESS AGE, you should have no difficulty in connecting up a receiving set of this type.

The high voltage condenser for your Thordarson transformer should consist of four plates of glass, 14 inches by 14 inches, covered with tinfoil, 12 inches by 12 inches. If the glass will not withstand the potential of the secondary you should make up sixteen plates, putting eight plates in parallel in a bank and connect two banks in series.

* * *

L. D., Wisconsin:

The majority of three-element vacuum valve detectors which are not highly exhausted are more or less erratic in action and require frequent readjustment. It is difficult to state just what is wrong with your particular bulb, but it is quite probable that it is

exhausted to that degree where the adjustment is extremely critical. It may be, however (from your explanation) that at certain adjustments, this valve is set into oscillation; therefore it distorts the spark note of the transmitting station and since the bulb does not remain in stable oscillation the signals are interrupted.

* * *

B. R. K., Nashville, Tenn.:

Telegraph relays have been connected in the local telephone circuit of the vacuum valve and have been employed to operate calling apparatus, but obviously the bell would ring during atmospheric discharges as well as during the reception of radio telegraphic signals. hence such an arrangement would be of little value for the purposes you require.

The coherer is used in the power stations of the New York Edison Company for determining the nearness of a thunder-storm. When lighting discharges become rather frequent, even when not in sight of the power stations, the coherer will actuate a recorder or call bell, and the increasing violence of its action will determine the probable distance of the storm.

* * *

R. M. P., Fort Smith, Ark.:

We do not know the constituents of the "Lenzite" detector.

* * *

K. V. R. L., Worcester, Mass.

We have no absolute record of the longest distance covered by an amateur set, but we have had reports that 1,400 miles have been covered during the night hours at the wave-length of 200 meters. It is not possible to consume 1 K. W. at the wave-length of 200 meters efficiently; in fact with a well designed set, owing to the restrictions of the closed circuit condenser, the transformer would not consume more than ½ or ¾ K. W.

We have no data on multi-layered windings, such as you require, but you can easily determine for yourself the correct number of layers or turns for a given station by listening in to some station the wave-length of which is known. With the present war restrictions, you will be required to discontinue your experiments until peace has been declared.

We do not advise the use of No. 36 wire for the secondary winding of a receiving tuner except in connection with a vacuum valve detector. In practically every case No. 32 S. S. C. wire is preferred.

* * *

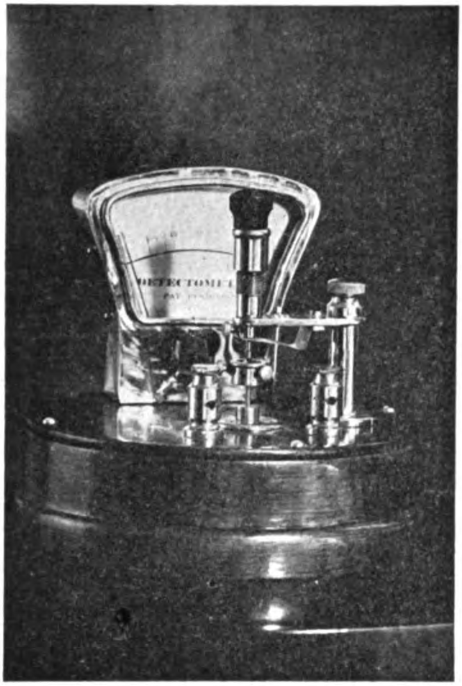
E. T. D., Toronto:

A wiring diagram of the Marconi 5 K. W. transmitting set is not available for publication.

* * *

R. J. M., Green Park, Pa.:

The three-element vacuum valve is generally considered the most sensitive of all receiving detectors.



Detectometer—A combination of detector and indicator

A Novel Wireless Instrument

The accompanying illustration shows a unique and interesting wireless device known as a Detectometer. It is a combination of a detector and a meter or indicator and can be used in place of any detector in connection with wireless telegraph or wireless telephone apparatus. It may be assumed that for given crystals the pressure for the most sensitive spot is practically uniform. During readjustment the correct pressure can be secured by noting the reading of the dial. When adjusted the detector will stand up under the most severe shocks, such as gunfire on board ships. During actual tests the instrument has held its adjustment for six months and probably would remain so indefinitely if properly protected from the local transmitter.

The crystal holder and points are easily replaced should the occasion arise to do so. This instrument has been tested on ships as well as on land by the U. S. Government. Many operators have given it their thorough approval.

A Code Practice Set for Continuous Service

Now that the amateur cannot work on account of the war he has a good opportunity to brush up on his sending and receiving without getting into trouble with the authorities. This he can do by means of the usual key and buzzer set, but it is not a very satisfactory method.

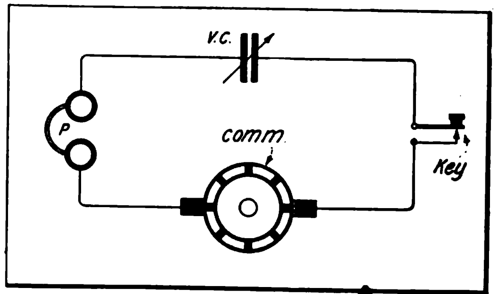


Figure 1

While experimenting to reproduce radio signals I hit upon the following plan which the average amateur can duplicate with the apparatus at hand.

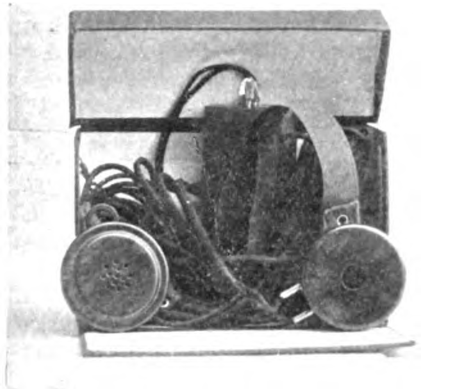
Using the ordinary 110 volt A. C. high speed rotary gap motor, connect a pair of telephones in series with a key and variable condenser across the brushes of the motor. By varying the capacity of the condenser the intensity of the signals in the telephones may be increased or decreased, and by connecting a variable resistance in series with the motor the pitch of the signals may be varied at will.

By using several keys and telephones in parallel and mounting the whole on a long table a suitable apparatus for teaching the code may be had. Three or four amateurs "sitting in" on a set of this sort can carry on conversation as they were wont to do before the closing of their stations by the government.

Editorial Note.—The use of a motor for energizing a code practice circuit was first adopted by the Marconi Institute many years ago. By proper adjustment of speed and by the employment of a 2 microfarad condenser in series, a perfect imitation of a 500 cycle transmitter is secured.

A Unique Micropho-Detectagraph

The accompanying illustration shows a novel micropho-detectagraph transmitter which is said to be a supersensitive microphone. It has been used by wireless operators and experimenters for the amplification of incoming signals.



A supersensitive microphone

It is pointed out that at no time in the history of American achievements has the nation been so stirred as by the remarkable exposures made in public and private life by the use of ingenious detective devices of sound-reproduction. As the word "Micropho-Detector" implies, it is the unseen detective. It hears everything—the slightest sound or whisper—and transfers the information to a receiving telephone connected in the circuit at a distant point.

This super-sensitive instrument may be concealed in the walls, behind a picture or desk, or in any article of furniture. The transmitter or sound collector is 2¼ inches in diameter, ½ inch thick, and weighs only two ounces.

One or more pairs of receivers can be used, according to the number of witnesses required for corroborative evidence. These receivers are so constructed that the vocal tones of persons are retained with all individual and identifying characteristics. Transmitter, earpieces, two standard dry cell batteries, regulator cord and case, complete the circuit. A room may be

equipped with micropho-detector in a moment's time by anyone. It does not require any technical knowledge to operate it. Full instructions as to how to install and operate it are included with each outfit. Conversation carried on in an ordinary tone is taken up by the concealed micropho-detector sound collector, magnified and conveyed over wire to a stenographer.

It is stated that by its use the stenographer or listeners at the receiving end, which can be in the adjoining room or some distance away, are enabled to hear every audible sound made in the room where the transmitter is concealed, without any suspicion on the part of the suspects. The micropho-detector is used in many government, state, county, and city offices and by the railroad corporation, banker, manufacturer, and in fact, to all who at any time have need to secure information or evidence. Many bankers' desks and directors' rooms are fitted with the micropho-detector in order that a record by a stenographer may be made of any important conference.

Railroads use the detectagraph to guard against attempts of blackmail or perjury in offering testimony in damage suits. Insurance companies utilize the device when contests arise over payments of insurance policies. Jails and penitentiaries may have a number of cells equipped with this detector, and thus record conversation between convicts and friends.

The originator of the micropho-detector modern detective devices has for many years been actively engaged in secret service work. The inventor has used these detective devices in securing corroborative evidence in an attempt to blackmail a railroad corporation of $75,000. He saved a prominent insurance company $150,000 in an attempt to collect upon a policy and in numerous other instances has successfully exposed trickery and fraud. He claims that this instrument clearly and distinctly reproduces sound however faint and correctly transmits it so that any person may hear the conversation of others without detection or interference.

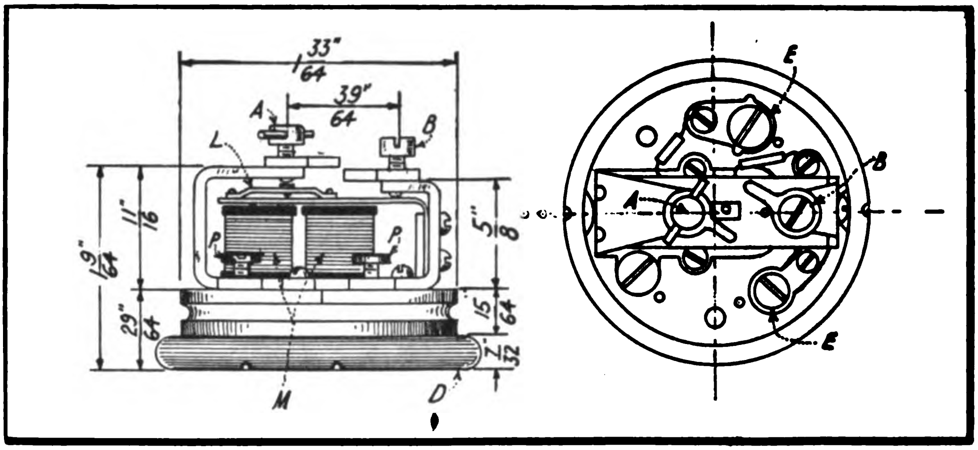


Figure 1

Signal Corps Model High Frequency Buzzer

An electrical supply house has recently placed on the market a high frequency buzzer especially designed for Signal Corps use. A plan and side elevation are shown in figure 1. Two magnet coils M are mounted on a composition base, such as bakelite. A brass arm holds the adjustable contact A, and another arm the plate tension adjusting tube B. The contact S on the armature F is attached rigidly by means of two rivets. Mounting the contact on the armature in this way permits a very high pitched note to be obtained.

By adjustment of either A or B, the tone of the buzzer may be varied over a wide range of frequency. These buzzers are applicable to code practice or to the testing of oscillation detectors, or for any purpose where shock excitation of a radio frequency circuit is desired.

An Efficient Receiving Detector

I have shown in the drawing, figure 1, a detector of the ball and socket type which has the adjusting arm in a vertical position. I have found it to be an

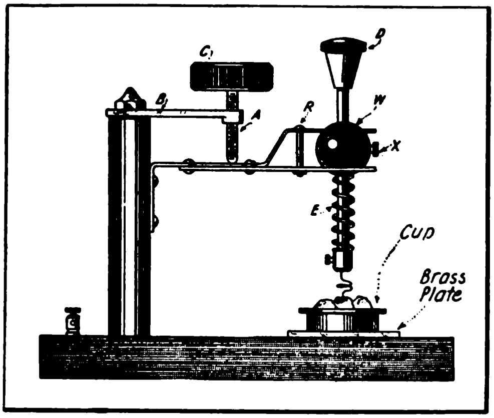


Figure 1

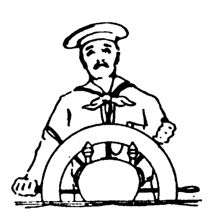
efficient one and particularly easy in point of adjustment. It will be noticed from the drawing that the vertical adjustment arm has the spring key which holds the sharp point in a state of tension against the crystal. It will be observed that the movement of the ball may be regulated by the set screw R, which holds the piece of spring brass or phosphor bronze W in close contact with the ball. The additional material required is a ⅜-inch square rod, an 8/32 brass bushing A, a piece of ⅛-inch brass B, the knobs C and D, and a 3/16-inch brass rod C. The length of the rod E may be adjusted by the set screw X, and coarse adjustment of the contact point made by means of the knob C, which places a tension on the spring.

J. G. Stelzer, *Michigan.*

(*Continued from page* 691.)

mitting and receiving apparatus in such a way that it cannot be quickly connected up. Certain well intentioned enthusiasts have thus been left open to unnecessary suspicion, and placed in a most uncomfortable position.

The Government orders on this point must be strictly observed. ***The aerial wires must be taken down, the apparatus dismantled and sealed up,*** i. e., it must be sealed in such a way that it cannot be readily connected for working.



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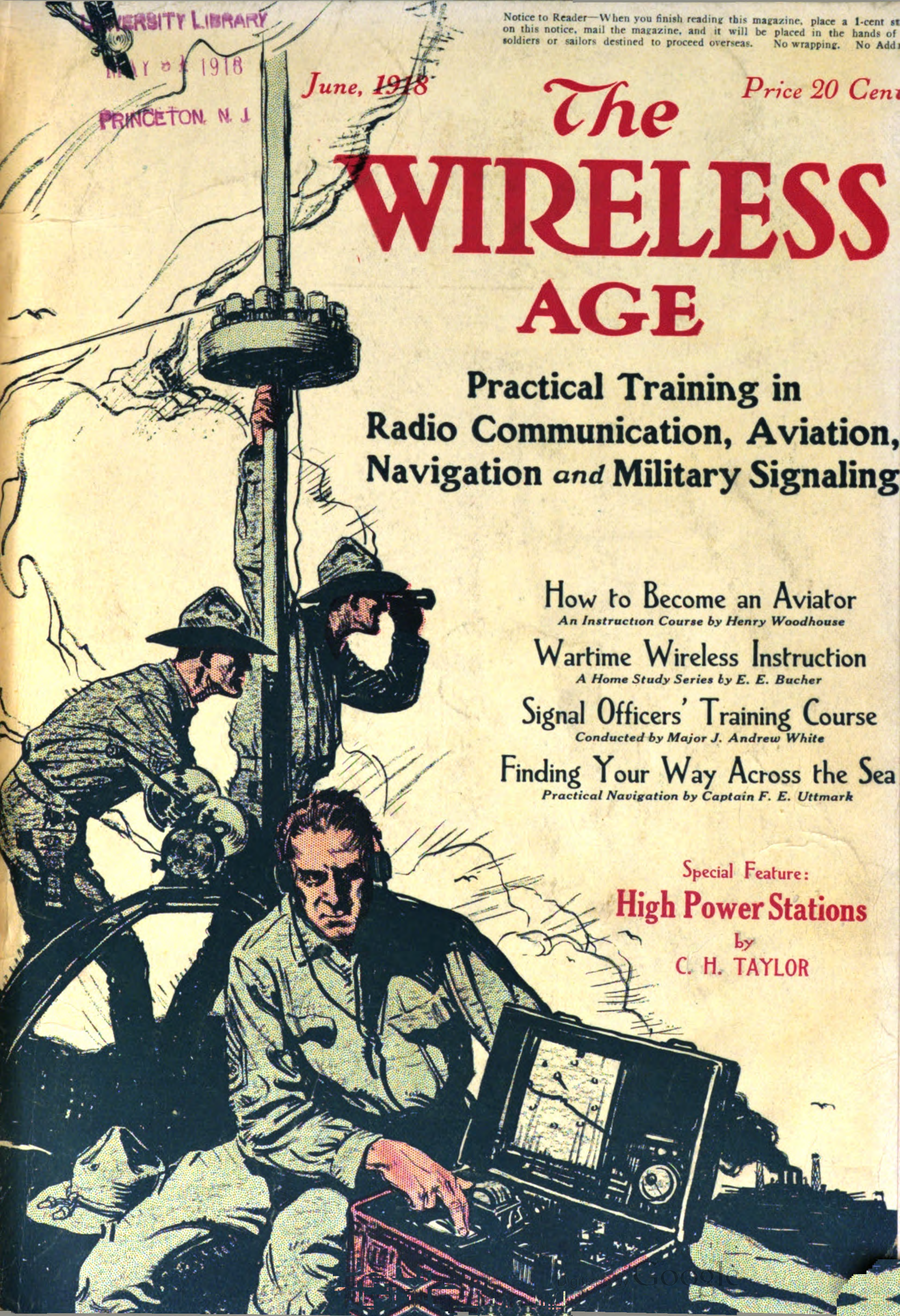

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C. H. TAYLOR

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That remarkable body of men, the British Royal Engineers, are represented here with radio pack set in field operation, receiving reconnaissance reports from an airplane scout

THE WIRELESS AGE

WORLD WIDE WIRELESS

Naval Radio in a Year of War

THROUGH the Committee on Public Information, the Navy Department has issued the following statement of its activities in radio communication in the first year of America's participation in the war:

The President on April 6, 1917, directed the Navy Department to take over such radio stations as might be required for naval communications, all others being closed. The enforcement of this order fell to the Director of Naval Communications, and 53 commercial radio stations were taken into the Naval Communication Service. On account of duplication, 28 commercial radio stations closed. Thousands of small amateur radio stations were closed. At present no radio communication is permitted on United States territory (not including Alaska) except through stations operated by this department or by the War Department.

Soon after the war opened the demand for radio operators increased and the representative of the Naval Communication Service in each district began conduct of a radio school for preliminary training in radiotelegraphy. To co-ordinate training, a central final training school was demanded. Harvard University early last summer offered the use of buildings, dormitories, and laboratories for this purpose, and the offer was accepted. From a small beginning, the naval radio school at Harvard has now developed into one of the largest educational institutions in the country.

At Mare Island, Cal., is located another final training school. At these two schools men are put through a four months' course, which embraces not only radiotelegraphy and allied subjects, but the military training necessary for all enlisted men. At present nearly 5,000 men are under instruction in these two schools alone. Classes are graduated each week and operators are assigned to service. Applicants for this service are accepted at any Navy recruiting office.

The Navy is providing the required operators for the rapidly increasing list of naval ships. It has also undertaken to supply radio operators for all merchant vessels in trans-Atlantic service, and is, to this extent, assisting the Shipping Board in manning such vessels.

The Naval Communication Service provides for communication by radio between the United States and its Asiatic possessions and territories. During the past year the high-powered stations at San Diego, Cal., Pearl Harbor, Hawaii, and Cavite, P. I., have been completed and put into commission. The Naval Communication Service also provides direct radiotelegraphic communication between America and Europe, and as part of this service it recently announced the accomplishment of the first radiotelegraphic communication between Italy and America.

Marconi Damage Claim for British Imperial Chain Admitted

THE stir-up in the British Parliament several years ago which acquired the misnomer "Marconi Scandal" held the limelight once again in London, in the middle of March. The suit of Marconi's Wireless Telegraph Co., Ltd., for damages growing out of the repudiation of the contract awarded it to build an Imperial Wireless Chain of stations for the British Government, reopened the controversy, which is expected to disclose some hitherto unknown facts governing pre-war ministerial actions, although the Attorney General has already admitted the Marconi Company's claim for damages.

It has come about in this way: In 1913 a Select Committee was appointed by the House of Commons to investigate and report upon the development of wireless telegraphy, with Sir Charles Hobhouse, a sometime Liberal officeholder, as chairman. Among the members of the committee was Henry Norman, M. P., since created a Baronet and a member of the Privy Council.

In July of 1913 the then Postmaster General, Herbert Samuel, entered into a contract with the Marconi Company for the construction and installation of an "Imperial Wireless Chain" at specified points throughout the British Empire. In December of 1914 the new Postmaster General, Sir Charles Hobhouse, repudiated the contract with the Marconi Company, and the company brought suit against the Government for a declaration that this repudiation was wrongful, claiming damages.

This suit was brought to trial a month ago and terminated somewhat strangely by the Attorney General suddenly abandoning the defense on behalf of the Government, agreeing to the declaration which the Marconi Company sought and admitting its claim for damages.

Godfrey Isaacs, Earl Reading's brother, as managing director of the English Marconi Company, produced a letter at the trial which forms the basis of the present promising affair. When Sir Charles Hobhouse became Postmaster General, in 1914, he went to Berlin to see for himself what the Germans, especially the Telefunken Company, were doing in perfecting long-distance wireless, and took Sir Henry Norman with him as interpreter, the latter speaking German and being well acquainted with the technology of wireless. After their return from Berlin, Godfrey Isaacs received a letter from two friendly directors of the Telefunken, saying that Hobhouse and Norman had suggested that the Telefunken should tender for the second trio of British imperial wireless stations for which the Marconi had already a provisional contract. The Telefunken reply was that they could not hope to undercut the Marconi in England, as the expenses of the Telefunken, owing to the cost of licenses, etc., would be higher than those of the Marconi, besides which their patent position in England was uncertain. The Telefunken directors' letter went on: "From this Norman formed the opinion that there would be little question of relying upon the Telefunken Company as a competitor of the Marconi in England, and he therefore approached Herr von Lepel with the object of encouraging him to form an English company and to obtain for him financial assistance. With this object, among others, we understand, these gentlemen are endeavoring to obtain financial assistance from Mr. Beit" (presumably the South African millionaire).

That the British Postmaster General and a member of Parliament (Norman held no official position at this time), should offer inducements to a German undertaking to come and cut the ground from under a British one would not have been popular even when it was alleged to have been done, while in the present state of feeling, it is a very ugly business indeed, and is so accepted by these two gentlemen, who both indignantly denied in the House of Commons that they had ever made such a suggestion to the Telefunken Company.

When the suit came on Hobhouse was subpoenaed by the Marconi Company, but, as already stated, the Attorney General for the Government suddenly surrendered before either Hobhouse or Norman gave evidence. They

both made statements in the House of Commons absolutely denying the allegation of the Telefunken directors, but some members wanted to know why they had not done so in the witness box, where they could have been cross examined, instead of the House, where Isaacs was not in a position to challenge them. He wrote to the press the next day reaffirming everything he had said in his letter to Postmaster General Pease, and inviting Hobhouse and Norman to repeat their statements outside the House so that he could take legal proceedings to substantiate them.

Sir Charles Hobhouse has replied declining to do this, and Godfrey Isaacs has rejoined that he is not going to let the matter rest.

Dr. Braun, Famous German Scientist, Dead

DR. FERDINAND BRAUN, eminent German scientist, who shared the Nobel prize with Guglielmo Marconi in 1905 for distinguished achievements in the invention of improved methods for wireless telegraphy, died a prisoner in the Kings County Hospital, New York, April 19th, from heart disease, which was superinduced by an overdose of morphine.

Dr. Braun was found unconscious in his room in the home of his son, Conrad Braun. On a table beside him were two empty bottles, which the police charged had contained morphine, and another bottle partly filled with the same drug. Relatives of the scientist summoned a policeman, and he sent in a call for an ambulance.

Dr. Blauvelt hurried the unconscious man to the hospital, where ineffectual efforts were made to restore him to consciousness. Pending Dr. Braun's expected recovery, a charge of having narcotics in his possession was made against him, but he died without being able to make any explanation of how the drug came into his possession.

His son told the police he knew of no reason why his father should have attempted to take his own life, and that the overdose of the drug must have been taken by accident. In the police records Dr. Braun is listed as a music teacher.

Dr. Braun came to this country from Germany early in 1914 as a witness in litigation between the Marconi Wireless Telegraph Company and the Atlantic Communication Company which built and operated the wireless station at Sayville, L. I.

In Germany he was called the "wireless wizard" and was credited there with having done more than any one else to perfect control of the new system of communication.

Marconi, upon the outbreak of the European war, was summoned hurriedly back to Italy to take his place as an officer in that country's army. As a result, the litigation which had brought Dr. Braun to this country was indefinitely postponed. He was taken ill and was reported to be dying immediately afterward. Dr. Braun was born in Fulda, Germany, in 1850, and early became interested in scientific research work.

He studied at several universities in Germany and then went to Scotland to complete his education. Returning to Germany he taught for several years at Karlsruhe, but in recent years he was professor of physics at the University of Strassburg. At various times he also held important posts in the schools of physics at Wurtemburg, Leipsic and Tubingen.

Wireless telegraphy claimed Dr. Braun's attention in 1898, and for many years after that he applied himself almost exclusively to the task of solving its problems.

Dr. Braun had written extensively on wireless subjects and was well known in this country through his many contributions to the Electrician and other scientific journals.

Funeral services were held April 23rd. The Rev. Dr. William Jung, of

the German Lutheran Church, conducted the services in German. He made a plea for a spirit of fairness on the part of German aliens toward the United States, and said that if all Germans in this country had judged the nation as fairly as the dead man had done, there would not be such a strong feeling against German aliens.

Great Britain's Use of Women Telegraphists

ENGLISH GIRLS are qualifying fast for positions as wireless telegraphists, says the Pall Mall Gazette. They have not yet been placed on ships, the objections being that they cannot shin up the masts and make repairs.

They are, however, being used extensively in some high power land stations. Some time ago England started a special training school for women in North Wales, only accepting applicants who are already experienced post office telegraphists. The Government gives them additional training in wireless work, and when they become expert in slip reading, punching, record reading, sending on long lines and the general duties of a commercial wireless station, they are drafted out as required. They go on night duty in rotation.

New High Power Station for Japan

THE Japanese Budget for the next fiscal year contains an item of $350,000 for the creation of a new wireless station at Taira in Fukushima. This site is on the Pacific coast and is thought to be an excellent one for direct communication with America. The volume of communication has increased of late over 50 per cent. The present wireless station at Choshi will be used entirely for communicating with ships on the Pacific.

Chinese Naval Radio Station Proposed

NEGOTIATIONS for construction of wireless stations at Chefoo, Shanghai and other points in China have been in progress between representatives of a Japanese company and the Minister of the Navy, Admiral Liu Kuanhsiung, since last March, according to seemingly reliable information, says the Chinese National News Agency. A loan agreement with a Danish company has been canceled by the Chinese Government on payment of monetary compensation to the Danish firm.

The Japanese demand for the privilege of building wireless stations in China is said to be based on a claim that wireless is closely connected with the national defense of Japan. It is stated the Japanese proposed to lend more money to China for that purpose under conditions similar to those proposed by the Danish firm. The wireless stations are required primarily by the Chinese navy and not at present for commercial purposes, it is announced.

Count Szechenyi's Submarine Wireless Company Seized

SEIZURE of the Submarine Wireless Company of New York, incorporated at Albany in August, 1912, on the strength of a wireless invention by Count Laszio Szechenyi, who married Gladys Vanderbilt, was announced on May 3rd at the office of the Alien Property Custodian in Washington, D. C. The steps leading up to the seizure were conducted with the greatest secrecy.

About two-thirds of the stock is held by enemy aliens, principally titled Austrians and Germans. It was on the strength of this showing that the seizure was ordered, it is believed, and not because the company was suspected of hostile action or intent.

The capital stock originally was $100,000. This was later increased to $500,000, the amount now outstanding.

Among the titled persons listed as holding stock in the concern are Count Julius Andrassy, Prince Johann Lichtenstein, Count Stefan Szechenyi, Prince Louis Windischgraetz, Count Alex Andrassy and Count Paul Esterhazy.

High Power Stations

Some Features of the Long Distance Stations of the American Marconi Company

By C. H. Taylor

Engineer, Transoceanic Division, Marconi Wireless Telegraph Co.

WHILST the progress of wireless in the territories, colonies and dominions of the Entente Allies, though wonderful to a degree, cannot be discussed in print, that of America stands out for all the world to see. Especially is this the case with the erection and opening of long distance stations. The high power installations erected in New Jersey and Massachusetts by the Marconi Wireless Telegraph Company of America, for the purpose of long distance communication with the United Kingdom and Norway respectively, afford excellent examples of this activity. There are other important items in the Marconi programme into which it is not necessary for our present purpose to enter; but in view of the recent opening of the extension of the Marconi Pacific Service to Japan, it may be of interest to those who devote some attention to radio-telegraphic matters to have, as here set forth, an account of these important and up-to-date installations.

The general design of these stations was decided upon in the spring of 1912, and there was—so far as the radio equipment is concerned—no important modification made subsequently when the material was fabricated. Broadly speaking these stations, from a radio point, are members of an organized system designed for long distance communication throughout the world.

It can be readily seen that a group of powerful long distance stations can be operated most effectively if all members of the group are designed not as isolated units but as component parts of one large group. This is the procedure that has been adopted, and the wave-lengths and spark-frequencies assigned to

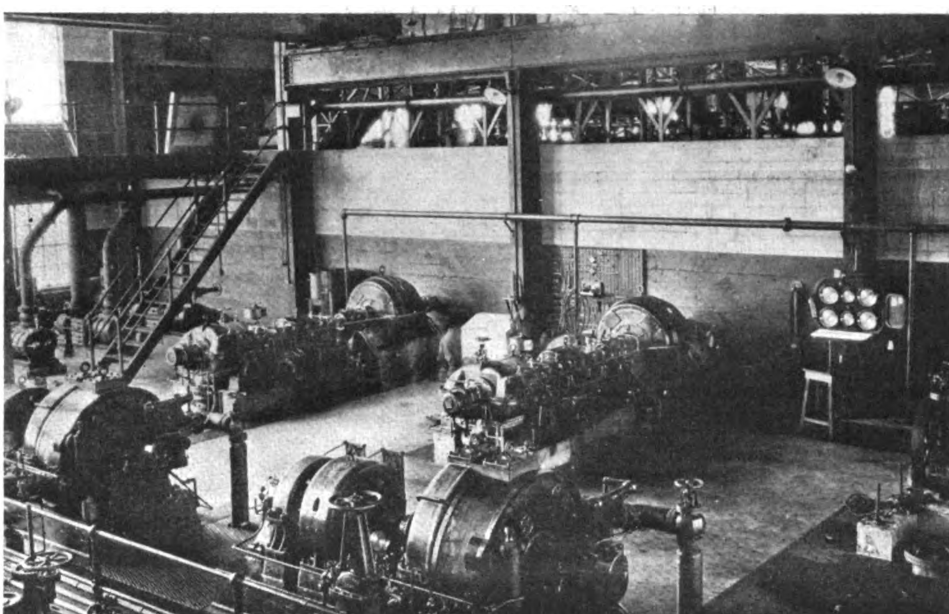


Figure 1a—Machinery floor of power house showing turbo-alternators, Kahuku, Hawaii

each of the various units were considered with greater reference to the complete group than to the individual circuit.

It is not our present intention to describe the power-supply equipment of these stations, as the points of greatest interest will be (*a*) those relating to the methods adopted to utilise effectively for radio work the primary power with which these stations are equipped, and (*b*) those relating to the success of these methods.

In the primary-power circuit the equipment at all these stations is similar. The unit for the supply of power to the radio circuits has a full load rating of 300 kw. An illustration showing a typical instance will be seen in figure 1a. It is in every case directly connected to the prime mover—either a steam turbine taking steam from their own steam mains; or a motor, taking power from public

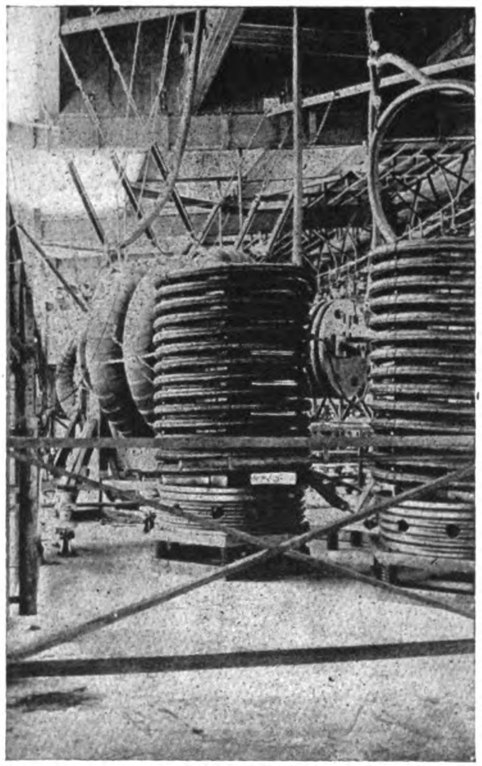


Figure 1b—High frequency inductance at Kahuku, Hawaii

service mains. The various accessory machines are driven from the same source of power, and are standard machines that call for no comment here.

These 300 kw. alternators possess special features of their own. The frequency is, from a power-station point of view, high; and varies for each station. This was deliberately arranged for, in order to assist in the selectivity at the receiving station. It was considered that it might not be possible to operate all the many proposed long-distance stations without some interference with each other, so the radio and audio frequencies are both varied with each station. The point of most interest about these alternators is that the stators of these machines are not fixed rigidly to the frames. The stator unit sits on a bearing inside the frame and is capable of being rotated thereon. The arc through which it turns is large enough to allow its position relative to that of the rotor

to be changed through an amount at least equal to the pole arc. These adjustments are made by means of a small hand wheel fastened rigidly to a threaded spindle. This spindle engages with a lug on the stator unit, and as the hand wheel is rotated, the stator is turned in relation to the rotor. A split collar and pinching screw are sufficient to hold this spindle in any desired position.

This type of construction was adopted because it was decided to drive the discharger through an extension of the rotor shaft and it was necessary to provide means for the control of the sparking instant. By the construction outlined above it is possible to make the alternator potential maximum occur at any desired position of the rotor shaft. The adjustment provided on the stator of the alternator is sufficient to allow the potential of the machine to be varied from O to its

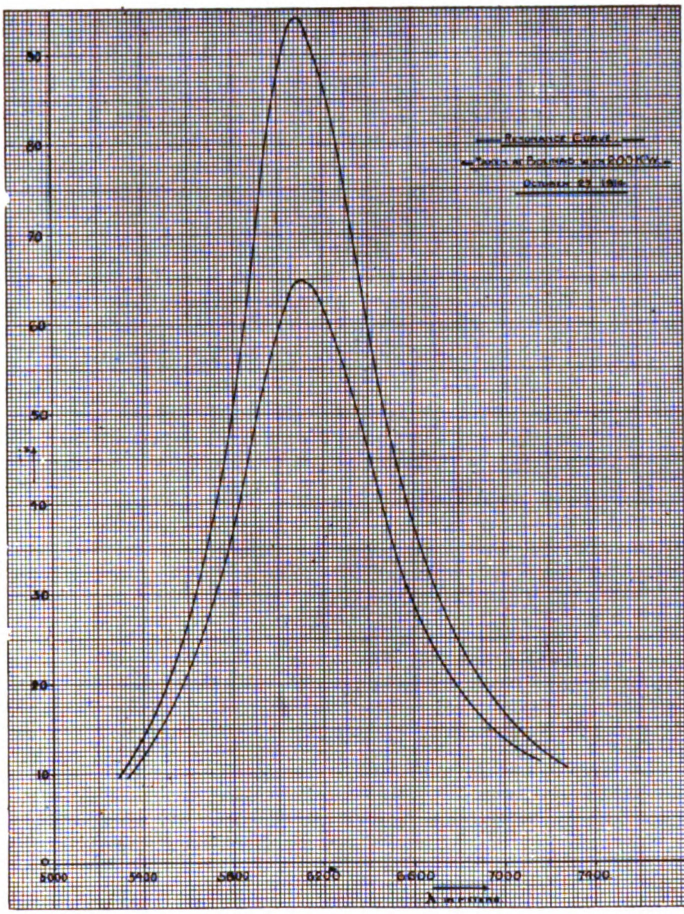


Figure 2—Resonance curve

positive or its negative maximum for the instant when the rotating studs on the discharger successively enter the spark zone. The correct position for the stator with relation to the beginning of each condenser discharge must be ascertained for each wave change as this position appears to vary with the make up of the primary radio circuit.

In practice these adjustments are not difficult. The circuit is loaded, and the power input held constant while the stator is turned until the reading on the wattless component meter is a minimum and that on the thermoammeter in the antenna circuit is a maximum. It has been found that the setting done at the

power house can be very accurate. Tests have been carried out over the long distance circuit to ascertain what error was liable to creep in by leaving this adjustment entirely in the hands of the transmitting station with the result that the receiving station audibility curve confirmed the transmitting station's adjustment.

Four resonance transformers each of 75 kva. rating raise the voltage at which the power is received from the alternator from 2,000 to a higher voltage at which it is more conveniently used in the primary radio circuit.

An interesting paper on the circuit has already been presented to the Institute of Radio Engineers by Mr. Hallborg, and for this section of the work readers are referred to his paper, which figures in the printed proceedings of the Institute. An example of a resonance curve will be found in figure 2.

The other feature of interest in this low frequency circuit is the operating control switch.

The control of the radio circuits for operating purposes has been placed in the condenser feeding circuit. This position has stood the test of exhaustive trials and is in common use at all Marconi power stations.

These switches make and break the circuit through which the charging current flows into the condenser bank. One of these switches is inserted in each line so that there is a complete break between the condenser and the feeding circuit. Each switch puts two breaks into the line that it controls. These switch keys are of the moving coil type operated by means of a change in the direction of the current flowing through one of the two sets of windings. Normally, the direction of the currents in the two groups of windings is such as to hold the switch arm in that position which makes a break in the high tension feeding line. When the direction of the current in one of these two groups of coils is changed, the switch arm moves over until it makes contact with a stationary contact holder; the high tension line is thus closed, and the current can then flow into the condenser bank and charge it. The distance through which these moving arms swing depends upon the rate at which operation is to be carried out.

Since the gap opened in this circuit is small and the voltage of the interrupted circuit is high, an arc will follow the break here every time the high tension circuit is interrupted. If this were allowed to persist, the signals would be distorted and rendered unintelligible. Consequently an air blast is played upon these contacts and the arc that follows each interruption is blown out.

In order that high speeds may be possible with these keys, the moving parts are made very light, yet sufficiently strong to withstand the tremendous hammering that they must endure when being operated at a good telegraph speed. The present type of key is the result of several successive eliminations of varieties that have been shown to have some defect, after being put through the severe test of commercial operation over an extended period.

With this key it is possible to operate cleanly at speeds of 75 words per minute, and the key has been tested up to a speed of 100 words per minute, without distortion of the signals.

The primary oscillation circuit naturally divides itself into three groups—the condenser bank and its connections, the coupling coil, and the discharger.

The units of this condenser are made up of thin sheets of zinc suspended in stoneware containers filled with insulating oil. Between each pair of zinc sheets is stood a glass plate approximately ⅛-inch thick. This type of condenser has proved in practice to have losses that are less than those developed in that type which has the conducting sheet pasted on to the glass plate.

The oil used in these tanks was carefully chosen and was forced through a filter press before being passed into the containers. An interesting fact has recently developed in connection with the oils used in condensers of this type. It has been found that condensers built in this fashion have, at certain stations, modified the characteristics of the oil during service. Units taken out of service after about a year's work have shown a fairly hard deposit on the surface of the

glass. This deposit, which is yellow in color, does not come away from the surface at all easily; in fact, it seems to get pressed tightly into it. In some instances when this has been removed from the glass the surface shows a clearly defined outline where the edges of the zinc sheet rested. Other instances have been reported in which this change in the oil is only one of thickening, in which the oil becomes changed to the consistency of vaseline. The oil has not been purchased from the same firm in all such cases, but has been bought in widely separated localities, so that it cannot be attributed to any one particular grade of oil. At present this oil change has not been noticed in the tanks that are known to have been supplied with oil forced through the filter press, so it is very probably due to traces of water in the oil.

As the spark frequency adopted at these stations is low, the energy per spark is correspondingly high. In order to avoid excessive potentials in the primary circuit, the value of the capacity has been kept large. In consequence, the condenser bank covers a rather large area, which has necessitated the careful design of the condenser buses and the arrangement of the tanks.

It is found absolutely necessary to have the buses and the tanks arranged so that they form an electrically symmetrical circuit. For convenience in operating, we have divided up the bank into a number of small groups, each of which is fed and discharged by a separate bus. Each of these group buses is of the same length, shape and relative space location, and these sets are joined to the main bus in as symmetrical a manner as possible, so that this bus will have a minimum disturbing effect on these units.

Moreover, practical experience shows it to be of the utmost inportance that the value of the capacity connected to each of these group buses should be identical. If this be not the case, any out-of-balance effect is at once made noticeable by surges which break down the air insulation between the buses, or which may break down the air-gap between the two halves of the condenser group bus. Instances of this splashing have occurred at points where, so far as can be seen, good balance is maintained, and investigation has disclosed the fact that there may exist along the tank bus potential differences at points that were to all appearances identical with respect to the electrical circuit.

In order to carry without much loss the heavy maxima currents, which occur on the discharge through the spark gap of this condenser, the main buses are each made of copper strip 24 inches wide and ⅛-inch thick. These two halves of the bus are set up close together, parallel to one another, and separated by an air-space which can be varied between limits. In this manner the inductance of these buses is reduced as much as possible.

In these stations the coupling coil is quite a massive affair. The primary coil, which has the larger diameter, is held stationary, and the secondary is mounted on a frame that allows it to be moved relatively to the primary, in order that the coupling between these two circuits may be varied. Our illustration in figure 1b will give a very fair idea of the arrangement. Each primary turn has a mean diameter of 5 feet, the external diameter over the winding being slightly more than 6 feet. Each of these turns comprises a number of cables laid around a non-conducting core—in this case of wood—which has a circular cross-section 12 inches in diameter. Each cable comprises 7 copper wires each separately insulated by a double cotton covering. The winding is laid around the core in a spiral fashion so that each cable makes at least one turn across the core while it is laid around the ring. In this manner all these wires are kept the same length between the ends of each turn; and each wire is electrically identical, ensuring, as far as possible, an equal current distribution throughout these cables.

The number of the above-mentioned primary turns varies at these stations from two to four.

The condenser is discharged by the well-known Marconi rotary disc type of discharger, built on a large scale, so as to enable it to handle the very large currents employed at these stations. The disc of this machine, figure 3, is 50 inches in diam-

eter. It is made of high tensile steel, and must undergo a test run for one hour at 3,000 RPM before being accepted. In station practice it is seldom run over 2,500 RPM. The electrodes fitted to this disc are copper studs having a cross section of 3 by 1 inches, the latter being the section in the direction of motion. The width of the side electrodes can be varied between the limits ¾ and 1½ inches.

With this type of machine, the discharge of the large condenser may be controlled so that at a reasonably loose coupling the energy may be efficiently transferred to the secondary circuit, and the radiation from that secondary circuit may be confined practically to a single wave length. In order to attain this end, it is necessary to proportion the sparking zone so that the duration of the spark and the time required to transfer the energy at the coupling used are in agreement. With these machines it is not very easy to gauge with absolute accuracy the length

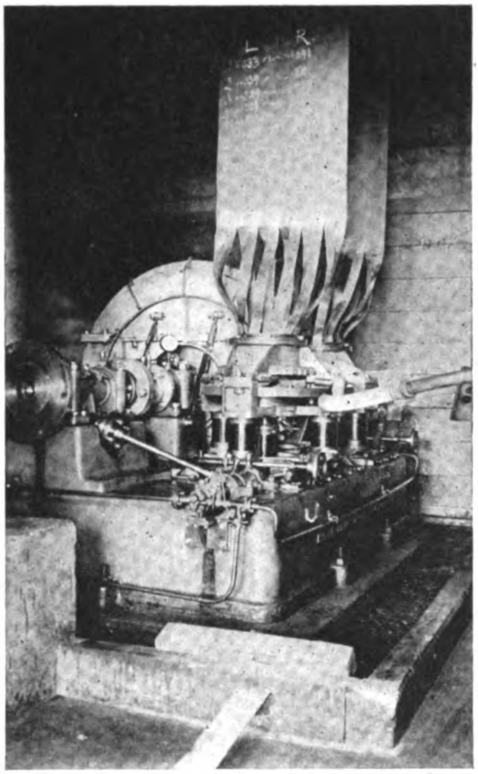
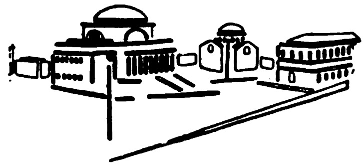


Figure 3—Synchronous Spark Discharger for high power station, 100 *to* 300 *kw.*

of the spark zone. The position of the stud at the beginning of the discharge can be ascertained from the known potential maximum, the dimension of the electrodes and the size of the gaps between the stationary and rotating members. This is held to the minimum needed to give mechanical clearance when all the parts have reached their steady working temperature. In general it will be of the order of 4/1000 inch in each gap. The position of the stud at the end of the discharge is not so definitely located. Since the speed of the machine is fixed, being determined by the alternator speed, any change in the duration of the discharge must be effected by alterations to the studs, or to the electrodes, or to both. Small variations can best be carried out by changes to the width of the electrodes.

(*To be continued*)

Progress in Radio Science



THE DYNATRON

A Vacuum Tube Possessing Negative Electric Resistance*

By Albert W. Hull, Ph.D.

Research Laboratory, General Electric Company, Schenectady, New York

(*Continued from May* WIRELESS AGE)

4. Dynatron in Circuit Containing Positive Resistance A. Series Connection. Circuit with Zero Resistance

If the dynatron is connected in series with a circuit containing positive resistance, the total resistance of the circuit is the algebraic sum of the positive and negative resistances, and may be made as small as desired by making the positive and negative resistances nearly equal. Such a circuit has very interesting properties. For, while the total resistance of the circuit is very small, that of its parts, individually, is not. Hence a small change in the e.m.f. applied to the whole circuit will cause a comparatively large change in current, and therefore in the iR drop across each part separately; i. e., the circuit acts as a voltage amplifier.

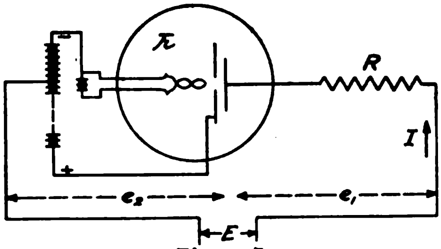


Figure 7

The connections are shown in figure 7. An ohmic resistance R is connected in series with a dynatron of negative resistance $\bar{r}$, the battery terminal of the dynatron being connected at the point V_0 corresponding to the voltage at which the dynatron current is zero.[2] (B, figure 3.) If an e.m.f. E be impressed across the combination, causing a current I to flow and a voltage drop e_1 in the ohmic resistance and e_2 in the dynatron, then

---

[2]The amplification of *voltage changes* remains the same if the battery terminal of the dynatron is at some other point than that corresponding to the point B in Figure 3, provided it be in the range A—C (Figure 3) over which the dynatron curve is straight. In that case the equations are

$$e_1 = I\,R$$

$$e_2 = I\,\bar{r} - I_0\bar{r}, \text{ where } I_0 \text{ is a constant}$$

hence $$E = I\,(\bar{r}+R) - I_0\bar{r}$$

$$\frac{de_1}{dE} = \frac{R}{R+\bar{r}}, \text{ that is}$$

voltage changes are amplified in the ratio $\frac{R}{R+\bar{r}}$.

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* Reprinted by permission from the proceedings of the Institute of Radio Engineers.

$$e_1 = I R$$
$$e_2 = I \bar{r}$$

Hence $$E = I\,(\bar{r}+R),$$

and $$\frac{e_1}{E} = \frac{R}{\bar{r}+R}$$

is the ratio of voltage across the ohmic resistance to total voltage, that is, the voltage amplification. This can evidently be made as large as desired by making $\bar{r}$ and R nearly equal, since $\bar{r}$ is negative.

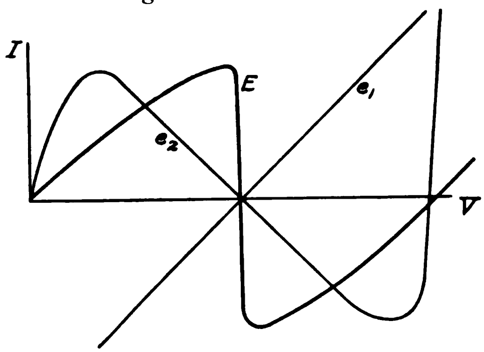


Figure 8

These relations may be clearly seen in the graphical representation of figure 8, where the three curves marked e_1, e_2 and E represent the current-voltage relation in the ohmic resistance, the dynatron, and the total circuit respectively.

With constant batteries, an amplification ratio of 1000-fold can easily be maintained. For example, if R represents a high resistance galvanometer of 2,000 ohms or more, an e.m.f. of 0.01 volt impressed at the terminals of the combination will cause an e.m.f of 10 volts across the galvanometer, with corresponding amplification of galvanometer current.

Further examples and applications of this principle to radio work are given in a later section.

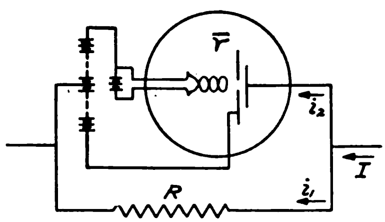


Figure 9

B. Parallel Connection

If the dynatron is connected in parallel with a circuit containing positive resistance, the total conductivity of the circuit, which is the sum of the positive and negative conductivities of its parts, can be made very small. The circuit then acts as a current amplifier. The connections are shown in figure 9. The total current I is the sum of the current i_1 through the positive resistance and i_2 through the dynatron.

Hence $$I = i_1 + i_2 = E\left(\frac{1}{\bar{r}} + \frac{1}{R}\right)$$

$$\frac{i_1}{I} = \frac{\bar{r}}{\bar{r} + R},$$ which may be made very large by making $\bar{r}$ and R nearly equal.

(C) Comm. Pub. Info.

Practice in transmitting information received by wireless from airplanes is afforded daily to our Signal Corps men making ready to go to France. The portable radio set shown can be erected in about a minute and connection by field telephone instantly established with the artillery bases

These relations are shown graphically in Figure 10, where the curves marked i_1, i_2 and I represent the current-voltage relation in the positive resistance, the dynatron, and the total circuit respectively.

The current I to be amplified may be that through a photo-electric cell, a kenotron, or any other non-inductive device the current of which is independent of voltage.

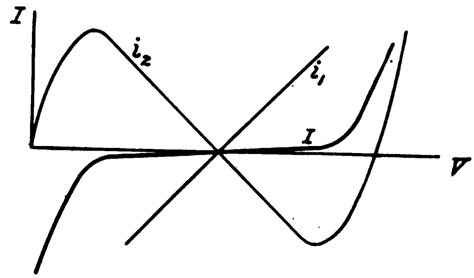


Figure 10

5. Dynatron in Circuit Containing Resistance, Inductance, and Capacity

If the dynatron be left open-circuited, as in Figure 1, it is unstable. This was to be expected as a necessary accompaniment of "negative resistance," and can easily be seen from the current-voltage relation in Figure 3. For when the voltage is greater than that corresponding to the point B, the plate is losing electrons, and hence becoming more positive; and the more positive it becomes, the more rapidly it loses electrons, until the point C is reached. Above C it continues to lose electrons, but more slowly, until it reaches the potential D at which it is in equilibrium. In like manner if the initial potential of the plate is less than B, it will continue to receive electrons until its potential has fallen to 0. At B the plate is in equilibrium, but the equilibrium is unstable, and if slightly disturbed, it will go to 0 or D.

The same instability occurs if the circuit of Figure 1, instead of being left open, is closed through too high a resistance, so that the rate at which the plate receives electrons is greater than the rate at which these electrons can flow away through the resistance. In this case the equilibrium voltages will not be D and 0, but some voltage in the range $D\,C_0$, and $O\,A_0$ respectively. This behavior may be strikingly shown by connecting a voltmeter between filament and plate, and opening the circuit. In this case the stable positions are 0 and a point just below D, and if the plate is originally at B, it will jump to either one or the other of these positions, depending on chance.

If the circuit contains inductance and capacity, as well as resistance, a similar action takes place. The plate charges up through the vacuum, at a rate depending on the capacity and negative resistance, and discharges through the circuit at a rate depending on the inductance and positive resistance. If the inductance is too high, the plate will receive electrons more rapidly than they can flow away through the inductance, and will charge up to some point beyond A or C at which the rate of charge and discharge are instantaneously equal. The inertia of the inductance will then carry it backward toward B, and if the resistance is not too great it will pass through B and oscillate continuously. Whether the circuit will oscillate continuously, or come to rest at B, or come to rest at some other voltage between 0 and D, depends on the relations between inductance, positive and negative resistance, and capacity. These relations can best be given by mathematical analysis, as follows:—

Let the dynatron, with negative resistance $\bar{r}$, be connected in series with a circuit containing inductance, L, resistance R, and capacity C, as shown in Figure 11. Then, calling the instantaneous e.m.f. across either part of the circuit E, we have:

For inductive part of circuit $I = \frac{E}{R} - \frac{L}{R}\frac{dI}{dt}$

For condenser $I + i = -C\frac{dE}{dt}$

For dynatron $i = \frac{E}{\bar{r}} + i_o$

which gives, eliminating E and i,

$$\frac{d^2 I}{dt^2} + \left(\frac{R}{L} + \frac{1}{\bar{r}C}\right)\frac{dI}{dt} + \frac{1}{LC}\left(1 + \frac{R}{\bar{r}}\right)I + \frac{i_o}{LC\bar{r}} = 0$$

the solution of which is

$$I = \frac{i_o}{R+\bar{r}} + A\,\varepsilon^{-\frac{1}{2}\left(\frac{R}{L} + \frac{1}{\bar{r}C}\right)t} \cos\left(\sqrt{\frac{1}{LC} - \left(\frac{R}{2L} - \frac{1}{2\bar{r}C}\right)^2}\, t - a\right) \qquad (1)$$

if

$$\left(\frac{R}{L} - \frac{1}{\bar{r}c}\right)^2 - \frac{4}{LC} < 0$$

and

$$I = -\frac{i_o}{R+\bar{r}} + A\,\varepsilon^{\left[-\left(\frac{R}{2L} + \frac{1}{2\bar{r}C}\right) + \sqrt{\left(\frac{R}{2L} - \frac{1}{2\bar{r}C}\right)^2 - \frac{1}{LC}}\right]t}$$

$$+ B\,\varepsilon^{\left[-\left(\frac{R}{2L} + \frac{1}{2\bar{r}C}\right) - \sqrt{\left(\frac{R}{2L} - \frac{1}{2\bar{r}C}\right)^2 - \frac{1}{LC}}\right]t} \qquad (2)$$

if

$$\left(\frac{R}{L} - \frac{1}{\bar{r}C}\right)^2 - \frac{4}{LC} > 0$$

where i_0, A, B, a are constants.

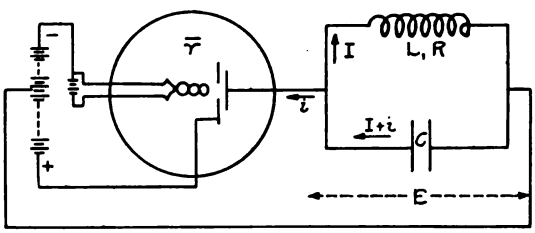


Figure 11

The case of most interest is the oscillatory solution, given by equation 1. This differs from the equation of a simple oscillatory circuit in that the damping factor is decreased from $\frac{R}{2L}$ to $\frac{R}{2L} - \frac{1}{2rC}$, where r represents the positive numerical value of $\bar{r}$, and the period is increased by increasing the damping correction from $\left(\frac{R}{2L}\right)^2$ to $\left(\frac{R}{2L} + \frac{1}{2rC}\right)^2$. It is identical in form with the equation of a circuit containing a leaky condenser, the positive leakage resistance of the condenser being replaced by the negative resistance $\bar{r}$ of the dynatron.

Two oscillatory cases are to be distinguished according as the damping factor is positive or negative. In the first case the circuit is stable, but its damping may be made as small as desired, so that an impressed oscillation will persist for a very

long time. In the second case, the circuit will oscillate continuously, with an amplitude that would become infinite if the negative resistance held over an infinite range, and which is therefore limited by the length of the straight portion of the negative resistance curve.

The criterion that the circuit shall generate oscillations is that $\frac{R}{L}+\frac{1}{\bar{r}C}<0$ or, if r denote the positive numerical value of $\bar{r}$, $Rr<\frac{L}{C}$ (3)

In order to test this relation, the inductance L in Figure 11 was made an air-core coil, and a secondary coil in series with a telephone was coupled loosely with it, in order to detect when the circuit was oscillating. With a definite value of negative resistance (determined by a separate experiment from the slope of the current-voltage curve) different capacities were introduced, and the maximum value of positive resistance was determined with which the circuit would still oscillate. The results are given in Table 1.

TABLE 1

R Ohms	r Ohms	L Henries	C Farads	Rr	L/C
75	3,000	0.689	2.90×10^{-6}	225×10^3	237×10^3
85	3,000	0.689	2.56×10^{-6}	255×10^3	269×10^3
96	3,000	0.689	2.26×10^{-6}	288×10^3	304×10^3
108	3,000	0.689	2.05×10^{-6}	324×10^3	334×10^3
126	3,000	0.689	1.75×10^{-6}	379×10^3	392×10^3
158	3,000	0.689	1.41×10^{-6}	475×10^3	487×10^3
204	3,000	0.689	1.12×10^{-6}	614×10^3	615×10^3
253	3,000	0.689	0.930×10^{-6}	760×10^3	725×10^3
78	6.520	0.689	1.27×10^{-6}	510×10^3	543×10^3
90	6,520	0.689	1.14×10^{-6}	587×10^3	602×10^3
116	6,520	0.689	0.90×10^{-6}	757×10^3	767×10^3
162	6,520	0.689	0.636×10^{-6}	$1,060 \times 10^3$	1.080×10^3
354	6,520	0.689	0.294×10^{-6}	$2,310 \times 10^3$	$2,340 \times 10^3$
674	6,520	0.689	0.150×10^{-6}	$4,400 \times 10^3$	$4,600 \times 10^3$

According to theory, the maximum value of Rr should be very near to, but always less than $L \div C$. It is seen that this relation is satisfied within the limits of experimental error. The values of Rr are all about 3 per cent. less than $L \div C$, which is the limit set by the sensitiveness of the telephone with the permissible coupling.

The frequency of oscillation is given by the equation

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}-\frac{1}{\bar{r}C}\right)^2},$$

in which the bracketed term under the radical is, for most practical circuits, negligible. The range of possible frequencies which can be generated is determined by the above equation, together with the relation (3) between resistance, inductance, and capacity. The limit of radio frequency is set by the minimum value of capacity, positive resistance, and negative resistance, and can be calculated if the distributed capacity and inductance of the coils and connecting wires are known. An ordinary dynatron short-circuited by a couple of turns of heavy wire will give a frequency of about 20,000,000 cycles per second, and it is possible to go continuously from this to a frequency of less than 1 cycle per second by simply changing inductance and capacity.

(To be continued.)

French Official Photo.

Pictures of an actual infantry charge are so rare that special interest is attached to this clear view of the commencement of a heavy patrol fight between French, Serbians and Bulgarians, north of Monastir

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By Captain Fritz E. Uttmark

CHAPTER VII.

Middle Latitude Sailing

IF a vessel sails from a place A to a place B, see figure 1, it is evident that she alters her latitude as well as her longitude and the formulas as given for parallel sailing must be modified. The course and distance from A to B or any two places may be found by Middle Latitude sailing. Solving this problem we need to know the latitude and longitude of the two places. Assuming latitude of A to be 40° 25′ N. and longitude of A 72° 15′ W.; latitude of B, 43° 15′ N. and longitude of B, 70° 30′ W. Proceed thus: Obtain the difference of latitude by subtracting the lesser from the greater if both places have latitudes of the same name, but add if of different names.

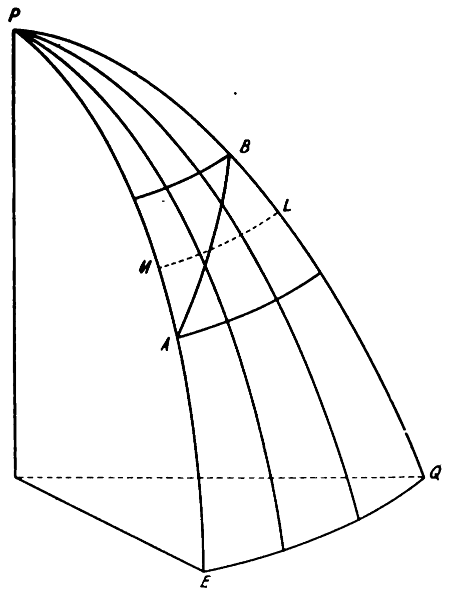


Figure 1

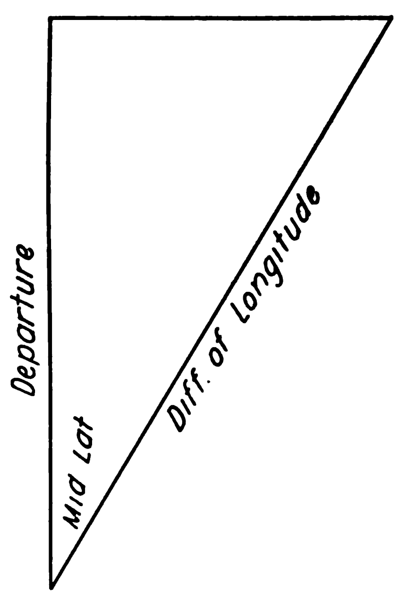


Figure 2

The result will be the difference of latitude expressed in degrees and minutes. Convert this into number of latitude or miles by multiplying the degrees by 60 and adding in the odd minutes.

The difference of longitude is found by addition or subtraction, following the same general rules as for latitude, namely: longitude of same name, subtract, of different names, add; the result is the difference of longitude expressed in degrees and minutes of longitude. Convert this into minutes of longitude by multiplying the degrees by 60 and adding in the odd minutes.

Example:

```
            Lat. A 40° 25′ N.                      Long. 72° 15′ W.
            Lat. B 43° 15′ N.                      Long. 70° 30′ W.
Diff. of Lat.      2° 50′           Diff. of Long.     1° 45′
                 x 60                                x 60
                  120                                  60
                + 50                                 + 45
   Reduced to 170 miles.             Reduced to 105 minutes of longi-
                                          tude
```

We have here one side of a triangle in miles and the other in minutes of longitude. This cannot be compared unless we convert the difference of longitude into departure or miles. If using the parallel of A (figure 1) for conversion we would on account of the meridians converging towards the pole be using a parallel which would give us too great a number of miles as departure, or using the parallel of B would give us too small a number of miles as departure. There must therefore be a parallel between A and B which used for the conversion would give us the correct result; although not absolutely accurate, this will be midway between the two places or the middle latitude which is found by adding the latitude of A and the latitude of B if of same names, or subtracting if of different names; dividing the result by two gives us the middle latitude.

```
               Lat. A 40° 25′ N.
               Lat. B 43° 15′ N.
Dividing by 2) 83° 40′
                      41° 50′ or 42° nearly.
```

Having thus found the middle latitude and substituting this for latitude in parallel sailing (see May number of WIRELESS AGE) we proceed exactly according to the rules given there: with the middle latitude of 42° considered as a course and the difference of longitude 105′ as a distance, we find the departure 80.4 in the latitude column. The departure is miles and therefore may be compared with the difference of latitude for finding the course and distance.

Entering Table II with difference latitude 170 and departure 80.4 we find latitude 170.4, departure 79.5, this being the nearest we can find and against this will be found True Course N.25°E. Distance 188 miles.

NOTE: We name the course North because the point of destination B is to the Northward of A and East because the same point is to the Eastward of A.

Example for practice:

What is the true course and distance from A in latitude 40° 25′ N., longitude 74° 00′ W. to B in latitude 32° 10′ N., longitude 64° 50′ W.

Answer, True Course S. 42° E.
Distance 670 miles

Mercator Sailing

In constructing a Mercator's Chart an attempt is made to portray a globular form on a flat surface. The meridians are shown as straight lines parallel to one another and at right angles to the equatorial line or the base of the chart. As the meridians are shown as parallels instead of converging, the chart would show a distorted and very much inaccurate miniature image of the surface of land and sea, unless the latitude scale of the chart is increased in the same proportion as the longitude scale is stretched out in order to allow the meridians to run parallel with one another. This is taken care of in the construction of an increasing latitude scale where each degree or each minute of latitude is a little longer than the preceding one reckoned from the equator towards the poles. The minutes of the Mercator's latitude scale are called *meridional parts* (m.). The values of these are computed and tabulated in Bowditch Table III.

Case I. The course and distance between two points A and B may be measured on Mercator's Chart or be computed according to the formulas given below.

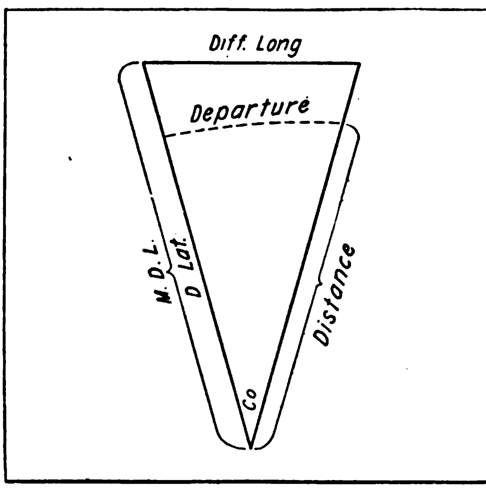


Figure 3

Given latitude A, 36° 40′ N., longitude A, 60° 45′ W.; latitude B, 34° 10′ N., longitude B, 0° 50′ W.—required true course and distance.

Obtain difference of latitude and difference of longitude according to the same rules as for middle latitude sailing. From Table III Bowditch take out the meridional parts corresponding to the latitude of A, also the meridional parts corresponding to the latitude of B. Subtract the lesser from the greater and call the remainder meridional difference of latitude M. D. L.

Lat. A. 36° 40′ N.	m=2353.7	Long. A 60° 45′ W.
Lat. B. 34° 10′ N.	m=2170.4	Long. B 63° 30′ W.
Diff. of Lat. 2° 30′	M. D. L. 183.3	Diff. Long. 2° 45′
x 60		x 60
120		120
+ 30		+ 45
150 miles		165 minutes of longitude.

Find the course according to the formula:

$$\text{Tang C} = \frac{\text{Diff. Long.}}{\text{M. D. L.}} = \frac{165}{183.3} \qquad \begin{array}{r} \log = 12.21748 \\ 2.26316 \\ \hline \log\ \text{tang.}\ 9.95432 \end{array}$$

Answer, True Course S. 41° 59′ 32″ W.

The distance is found according to this formula:

$$\begin{array}{ll} \text{Dist} = \text{Diff. latitude secant C} & \\ \text{Diff. Lat. } 150 & \log = 2.17609 \\ \text{T. C. } 41°\ 59'\ 32''\ \log \text{Sec} & = 9.12887 \\ \hline \text{Answer, Distance 201.8 miles} & 2.30496 \end{array}$$

Same problem may be solved by inspection.

Look in Table II Bowditch for the M. D. L. (183.3) in a latitude column, search until you find the Diff. Long. (165) in a departure column next to the M. D. L., in this case (found on page 614) 183.6 in the latitude column and 165.3 in the departure column. This being the nearest, we find the course 42° at top of page, and name the course S. 42° W.

Now having found the course, take the number of miles of diff. of latitude and look for same in a difference of latitude column, and the distance will be found in the distance column immediately to the left of the difference of latitude. In this case 150′ being the nearest, the distance is found to be 202 miles; both the course and the distance differ very little from the result obtained by computation.

NOTE: Middle Latitude Sailing may be used to the best advantage when the course is greater than 45° and Mercator Sailing when the course is 45° or less.

The Day's Work

Dead Reckoning is to find the position of the ship by courses steered and the distance run from some point or place, the latitude and longitude of which is known, allowing for known currents, leeway, set of the sea, variation and deviation. The day's work consists of a summing up of courses and distances run during the 24 hours ending at noon on any given day during a voyage and obtaining a fix by Dead Reckoning at noon.

As nearly always a course steered by the ship's compass has to be corrected for its errors, the first part of this problem therefore consists in correcting courses:

Leeway, deviation and variation have been explained in a previous chapter.

The course may be steered using a compass card which is marked in points and quarterpoints. This arrangement is generally used in sailing vessels or smaller steamboats or motor boats where it is more difficult to keep the vessel on an accurate course, or if the compass used has a card of small diameter. Larger vessels have generally a large compass which is divided into degrees. The compass used in merchant ships is divided into four quadrants, having North and South as zero points and East and West named 90 degrees. In the United States Navy the arrangement is different and the compass in general use has a continuous increase of the degrees and reads up to 360°, viz.:—

North being considered zero, East 90°, South 180°, West 270°, completing the circle of 360° again at North.

The table below may be used for converting points into degrees and one system of degrees into another.. The system referred to as used in the merchant marine is generally called the "Old System" and that used in the United States Navy is called the "New System."

Converting Points into Degrees and Vice Versa

Points	Old System	New System	Points	Old System	New System
North	O	O	South	O	180° 00′
N by E	N 11° 15′ E	11° 15′	S by W	S 11° 15′ W	191° 15′
N N E	N 22° 30′ E	22° 30′	S S W	S 22° 30′ W	202° 30′
N E by N	N 33° 45′ E	33° 45′	S W by S	S 33° 45′ W	213° 45′
N E	N 45° 00′ E	45° 00′	S W	S 45° 00′ W	225° 00′
N E by E	N 56° 15′ E	56° 15′	S W by W	S 56° 15′ W	236° 15′
E N E	N 67° 30′ E	67° 30′	W S W	S 67° 30′ W	247° 30′
E by N	N 78° 45′ E	78° 45′	W by S	S 78° 45′ W	258° 45′
East	N/S 90° 00′ E	90° 00′	West	S/N 90° 00′ W	270° 00′
E by S	S 78° 45′ E	101° 15′	W by N	N 78° 45′ W	281° 15′
E S E	S 67° 30′ E	112° 30′	W N W	N 67° 30′ W	292° 30′
S E by E	S 56° 15′ E	123° 45′	N W by W	N 56° 15′ W	303° 45′
S E	S 45° 00′ E	135° 00′	N W	N 45° 00′ W	315° 00′
S E by S	S 33° 45′ E	146° 15′	N W by N	N 33° 45′ W	326° 15′
S S E	S 22° 30′ E	157° 30′	N N W	N 22° 30′ W	337° 30′
S by E	S 11° 15′ E	168° 45′	N by W	N 11° 15′ W	348° 45′
South	O	180° 00′	North	O	360° 00′

Between O and 90° the course is N and E
" 90° and 180° " " " S " E
" 180° and 270° " " " S " W
" 270° and 360° " " " N " W

To Correct a Compass Course

Old System

Assume we stand in centre of compass looking toward the circumference
Apply Westerly Variation to the Left.
" " Deviation " " Left.
" Easterly Variation " " Right.
" " Deviation " " Right.
Leeway for Starboard Tack to the Left.
" " Port Tack to the Right.
The **result** is the **true** course.

New System (360°)

Westerly Variation and Westerly Deviation—Sub (—)
Easterly Variation and Easterly Deviation—Add (+)
Leeway for Starboard Tack—Subtractive (—)
Leeway for Port Tack—Additive (+)
The **result** is the **true** course.

A ship steered the following courses by her compass:

	Compass Course	Wind	Leeway	Dev.	Var.
No. 1	South	W S W	¾ pt.	¼ pt. W	1 pt. W
No. 2	S S W	West	1 "	¼ " W	1 " W
No. 3	S W	N W by W	½ "	¼ " W	1 " W
No. 4	West	S S W	1¾ "	¼ " W	1 " W
No. 5	W by N	N by W	1 "	¼ " W	1 " W

Required the true courses.

Answer No. 1, South; No. 2, S S E ¼ E.; No. 3, S S W ¼ W.; No. 4, W ½ N; No. 5, W S W ¾ W.

(*To be continued*)

Navigation News

The Greatest Maritime Nation

There were 37 steel shipyards in America at the time of our entrance into war. We have located 81 additional steel and wood yards, while 18 other yards have been expanded. Does America realize what this job means? Does it realize what a tribute is paid to its own initiative in this achievement?

We are building in the new and expanded steel yards 235 new steel ship ways, or 26 more than at present exist in all of the steel ship yards of England. If we had been content with doing the job in a small way, we might have built a few new yards, and added a little to our capacity. A few ships might have been finished more quickly; but it was the spirit and will of America to do the job in a big way, and the judgment of the country will be vindicated by the results when all these new ways are completed and are turning out ships. Many of these ways have actually been finished. The new industry we have created will make America the greatest maritime nation in the history of the world.

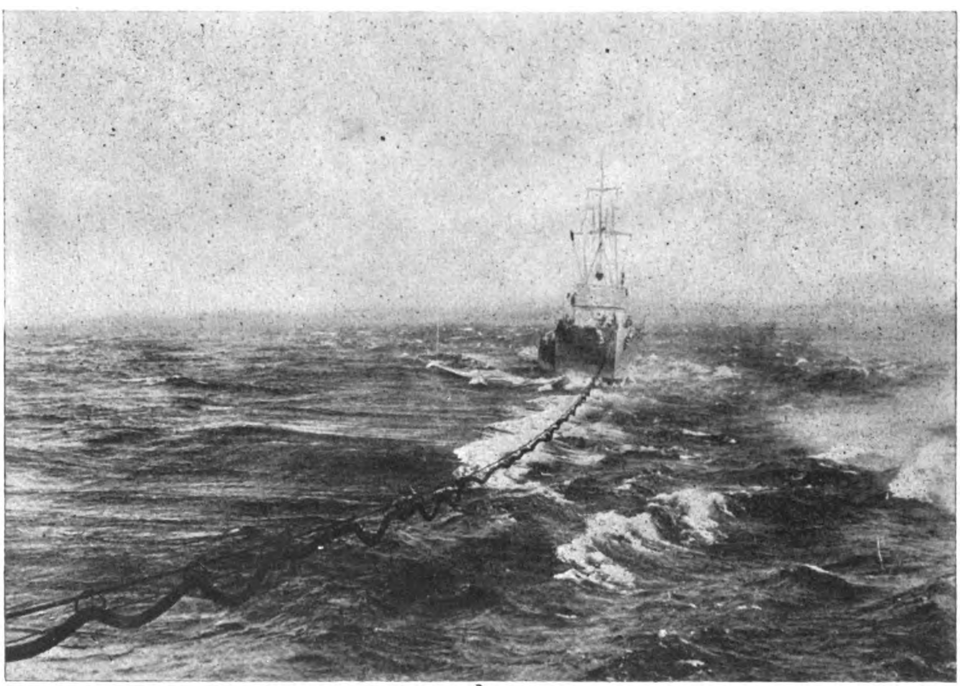
It took Germany forty years to build up her military machine. In less than eight months we have built up a shipbuilding machine, which, when it gets into full swing, will defeat the military machine of Germany.

It took Henry Ford, with all his genius for organization and standardization, sixteen years in which to develop his enormous production. It has required twenty years for the United States Steel Corporation to develop its activities to the point where they represent an organization, one-half as large as has been undertaken by the Emergency Fleet Corporation.

Hundred Hun Ships for U. S.

The Germans thought that by crippling their own vessels in American waters they would be able to prevent us from using them. American ingenuity and resourcefulness gave the answer by restoring these vessels to efficiency. With the expenditure of a little less than $8,000,000 we have succeeded in placing in our war service and in the service of the Allies 112 first-class German and Austrian vessels representing a carrying capacity of nearly 800,000 deadweight tons.

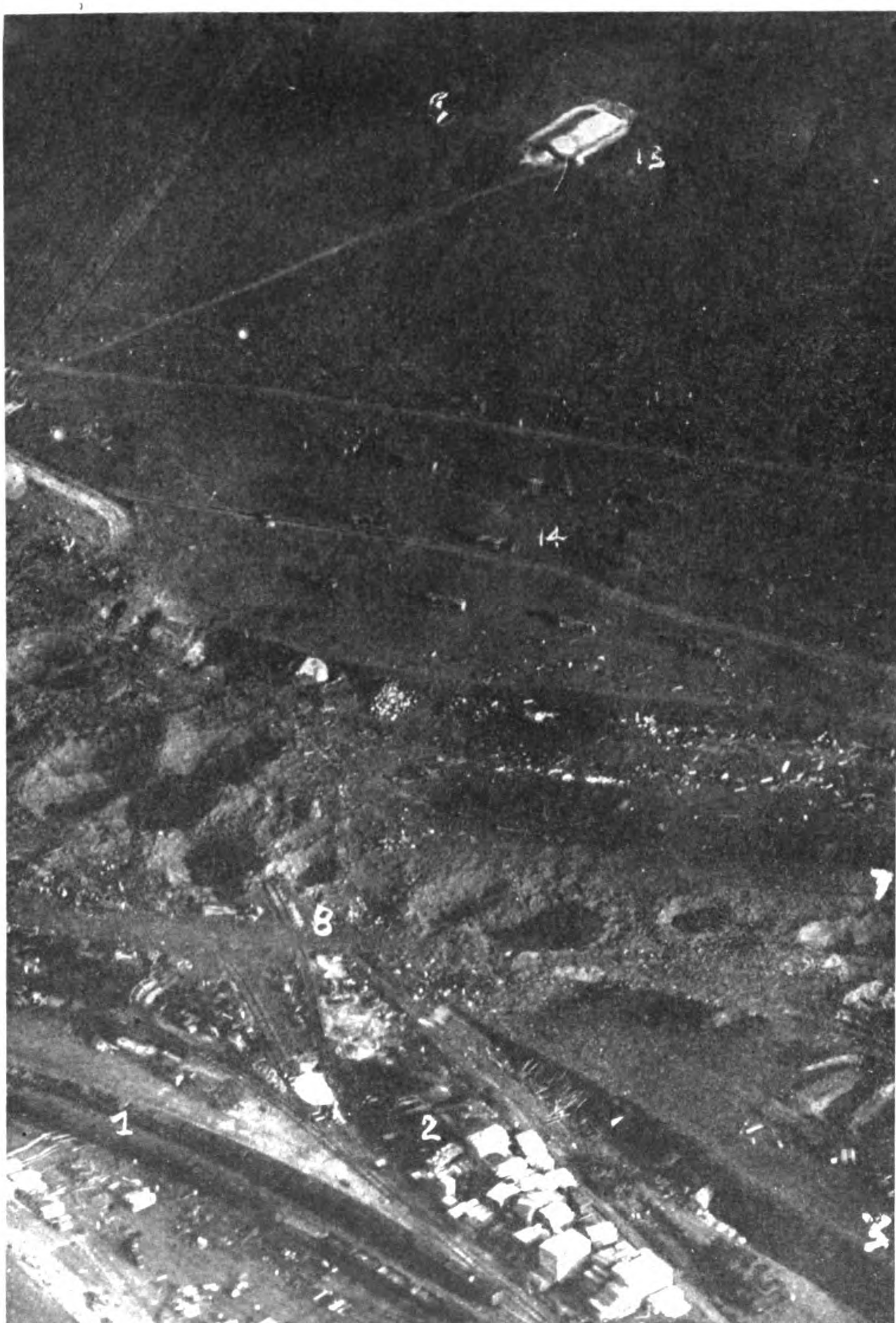
With our total of 730 wood and steel ways, we will have 521 more berths than Sir Eric Geddes in his recent speech stated England has at the present time.



The new method of supplying fuel to destroyers at sea is revealed in this view of an oil hose attached to a tanker

(C) Int. Film Svce.

This remarkable airplane picture, considered by the French to be the greatest ever taken, shows one of the biggest concentration camps at which munitions and men were assembled for the spring drive. Heavy French guns miles away, destroyed the railroad ***station, but the Germans*** *immediately built another terminal. Here is the official report of the* ***aerial photographer*** *on what the picture shows: 1—Supply railway trains running on* ***newly laid*** *tracks. 2—Piles of supplies, chiefly timbers for use in building* ***dugouts.*** *3—Rolls of barbed wire. 4—Piles of iron stakes for stringing barbed wire. 5—Steel*



roofing for dugouts. 6—Site of railway station before it was destroyed by French shells. Note big shell craters (about sixty feet across) caused by 420 M.M. shells. 7, 8, 9—Remains of former railway tracks where they entered railway station. 10—Broken ties of former railway tracks. 11—Other supplies piled up. Perishable goods covered over with tent cloth. 12—Battery of four guns, with abris for gunners. 13—Commander's dugout. 14—Ammunition park. Note German soldiers standing around. 15—German soldiers standing in the road watching the French airplane.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

By Major J. Andrew White
Chief Signal Officer, American Guard

THIRTEENTH ARTICLE

The Wire Company

Function and Employment

The wire company is the field signal organization used by the commander of a division for establishing and maintaining those tactical lines of information which radiate from division headquarters, and which serve, in general, to connect these headquarters with the major subordinate units. Normally the wire company is used to connect division headquarters with the headquarters of the various brigades within the division, with the divisional artillery, and, in some cases, with the divisional trains. Opportunity for its use in maintaining communication with the divisional cavalry will occur so rarely that its employment in this manner is prohibited except in emergency.

Organization

The wire company is organized into the necessary headquarters and company staff and two platoons of two wire sections each.

For drill the company is formed as above. In the field or on the march the company instrument wagon and the two reserve wire carts form a third platoon under command of the supply sergeant.

The organization, in detail, is as follows:

1 captain.
2 first lieutenants.
1 master signal electrician.
1 first sergeant (sergeant, first class).
1 supply sergeant (sergeant).
1 stable sergeant (sergeant).
1 mess sergeant (sergeant).
1 horseshoer.
1 clerk (corporal).
2 cooks.
1 farrier (corporal).
1 saddler (corporal).
1 mechanic (corporal).
1 assistant mechanic (private, first class).
3 drivers (private, first class).
1 guidon (private, first class).
2 buglers (privates, first class).
4 wire sections.

* The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

A Field Signal Battalion Wire Company, on road for practice

DUTIES OF INDIVIDUALS

The captain commands the company and is responsible for its training and efficiency.

The lieutenants command platoons, and will be assigned to such other duties as the captain may deem necessary.

The master signal electrician is responsible to the captain for the condition of the technical equipment of the company. To this end he will make frequent and regular inspections of same and, when parts of the technical equipment are found or reported unserviceable, will make or supervise the necessary adjustments or repairs. Under the direction of the captain, he will order such precautionary and corrective measures as he may deem advisable concerning the care and repair of technical equipment. Master signal electricians also act as substitute chiefs of platoons.

The first sergeant is the assistant of the captain, and is responsible to him for the general good order, police, and discipline of the company. In action he remains with the captain and under his immediate orders.

The supply sergeant is responsible to the captain for the care and preservation of the material not issued to the sections.

The stable sergeant is responsible to the captain for the general care of the public animals assigned to the company, the good order and police of the stables and picket lines, and the conduct of the stable personnel, when on duty.

The mess sergeant is responsible to the captain for the efficient and economical handling of the ration, for the conduct of the kitchen personnel when on duty and for the cleanliness of the company kitchen and surroundings.

The mechanics, under the orders of the supply sergeant, are responsible for the repair of the material pertaining to the company.

Chiefs of sections command the sections and will be held responsible to the captain for the condition of their equipment and the training and efficiency of their sections. They will make, or cause to be made, such minor adjustments or repairs to technical equipment as can be effected by the personnel of the section, promptly reporting more serious deficiencies to the master signal electrician.

The drivers are directly responsible to their chiefs of sections for their animals, harness, and equipment. They will report at once to their chief of section any injury to animals or matériel.

Drivers of combat vehicles not assigned to sections are likewise responsible to the supply sergeant.

The operators are responsible for the serviceable condition of their instruments and will report at once to their chiefs of sections any need of repairs.

The linemen are responsible for maintaining the section lines intact. They will carry the necessary equipment, and will report to the chief or section at once if their matériel is not in their possession or is unserviceable.

Messengers are responsible for the delivery of all messages, no matter what the conditions.

The Section

Composition

The wire section is normally composed of 13 mounted men and a wire cart and its driver.

The organization, in detail, is as follows:

1 section chief (sergeant, first class).
1 driver (private, first class).
3 station squads, each consisting of:

1 lineman 1 messenger 1 horse holder 1 operator Total, 14.	assigned by section chief from sergeant, corporal, private, first class, or private according to qualifications.

Formation

The mounted men of the section are formed in column of fours, as prescribed in The Soldier Mounted, the cart horses 2 yards in rear of the mounted men, and in such a position that the pole of the cart is in prolongation of the interval between the numbers 2 and 3 in the mounted ranks.

Posts and Duties of Individuals

The chief of section is on the left of the leading four, two or file, except that when the section is acting alone he may go where his services are most needed.

Each four constitutes a *station squad* and includes the personnel necessary to establish and operate one buzzer station. Each four is formed from right to left as follows: No. 1, the lineman; No. 2, the messenger; No. 3, the horse holder; No. 4, the operator.

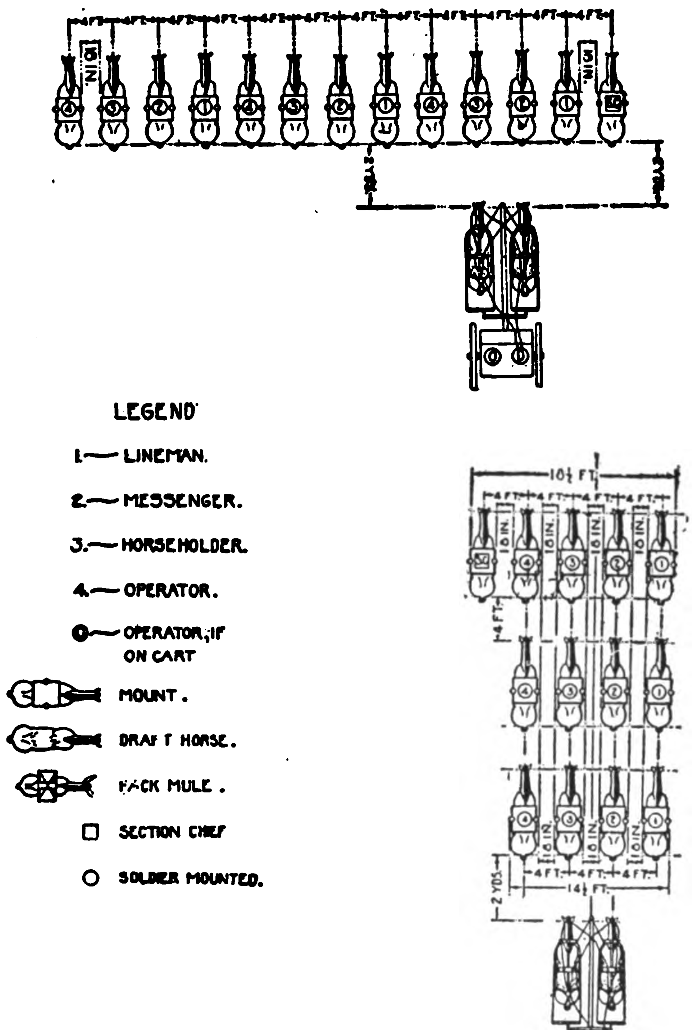
Where practicable, noncommissioned officers, except the chief of section, should be assigned to duty as operators.

To Open Station

To open station and move to the front from a halt: OPEN STATION. At this command the lineman of the first and second fours, the messenger of

the first four, and the chief of section turn out of the column, to the right, the horse holder and operator of the first four turn out of the column to the left. The two linemen, remaining mounted, prepare to follow the reel cart and lay out the wire, the lineman of the second four starting off in front.

The remaining men of the first four all move to the rear of the cart and dismount, except the horse holder, to whom the horses are turned over. The



THE WIRE SECTION
ABOVE—SECTION IN LINE
TO THE RIGHT—SECTION IN COLUMN

messenger unties the wire from the cart and pulls off enough slack and holds it or makes it fast to some convenient anchor. The operator prepares his buzzer, connectors, and ground rod, and opens the station in the location indicated.

When it becomes necessary for the lineman of the second four to stop for the purpose of making a tie, or for other reasons, he is passed or "leap frogged" by the lineman of the first four. This practice obtains whenever two linemen are working together, linemen using the "leap frog" method to the best advantage.

Laying the Wire

When the end of the wire has been removed from the cart the chief of section, or, in his absence, the senior present, at a signal from messenger, commands: DRIVE ON, at which command the cart, preceded by the men of the second and third fours, except the lineman of the second four, moves out over the indicated route, at first slowly, in order not to break the wire. The two linemen follow the cart attending the wire until the second station is opened, when the lineman of the first four returns back over the line to his station. His place is taken on the line work by the lineman of the second four, who is replaced by the lineman of the third four.

The manipulation of the machinery of the wire cart for handling the wire will be a part of the duty of the cart driver, unless an operator be placed on the cart, in which case the latter may handle the clutch. The reel must always be stopped before a march to the rear is taken up.

The chief of section rides near the cart, or wherever necessary in order to properly supervise the laying of the line. He will also designate a scout to precede the section from 100 to 200 yards and select a route in the immediate front for the cart to follow. The driver will conform to the signals of the scout. If the section is in march, it is halted before giving the command for opening station. As each station is established the operator will call up the initial station.

To Close Station

CLOSE STATION. At this command the lineman of the distant station immediately starts back over the line, laying out the wire in a convenient place for recovery. The operator of the distant station calls up all stations on his line, send G. B., and signs his station call, cuts out his buzzer, and mounts. The horse holder now mounts and prepares to attend the loop, using the spare pike which is lashed to the pole of the wire cart. The messenger takes the hand guard from the cart and feeds the wire upon the reel.

Recovering the Wire

REEL UP. At this command the wire cart moves off back over the line, reeling up the wire. As the loop approaches the cart the man attending it will call out *clutch,* when the driver will throw out the clutch in order to allow the loop to drop back.

Intermediate stations are closed by the command *close station,* and when the cart approaches the members of these stations take charge of the work of recovering the line back to the next station.

Members of the section not engaged in laying out or recovering the line ride in front of the cart. *This rule is general.*

As the cart approaches the end of the line an increased gait will be taken to gain sufficient momentum to reel up the slack. When all the wire is on the reel the section is re-formed in its proper place.

The Wire Platoon

Composition

The wire platoon is composed of two wire sections and is commanded by a lieutenant.

Formation

The habitual formations of the platoon are the *order in section column* and the *order in line.*

(C) Comm. Pub. Info.

This glimpse of Americans in France gives a close view of a communication trench of the Signal Corps with Major General Menoher and staff emerging after an inspection, news of his arrival being wig-wagged by the signalmen in the middle distance

A Field Signal Battalion laying the wires of communication along a road

The *order in section column* is that in which the sections of the platoon follow each other in the order, or the reverse order, of their numbers from front to rear. The distance between sections is 2 yards.

The *order in line* is that in which the sections of the platoon are formed abreast of each other in the order, or the reverse order, of their numbers from right to left. The interval between the sections is that which would result from the sections moving from the order in section column by the flank. This interval is approximately 16 yards.

Posts and Duties of Individuals

In the order in section column the post of the lieutenant is 4 yards opposite the center of the platoon, on the left when the first section of the platoon is leading and on the right when the column is reversed. In the order in line his post is midway between the two sections and in line with the leading fours of the platoon. When acting as an instructor he goes where his presence is necessary.

The lieutenant commands the platoon. The posts and duties of enlisted men in the platoon are prescribed in section II above.

Drill of the Platoon

The platoon is drilled in accordance with the principles and by the methods and means prescribed for the section and the company.

The captain may assign to platoons, for purposes of drill and instruction, such members of the company staff as he may deem advisable.

Signal Corps News

The Provost Marshal General has sent the following telegrams to the governors of all States:

Enlistment of Students of Electrical Engineering

Notify all local boards of the following amendment to section 151, Selective-Service Regulations. An additional sub-paragraph is added to paragraph "e" as follows:

"Under such regulations as the Chief Signal Officer may prescribe, a proportion of the students in institutions in which the Signal Corps has established a course in electrical communication, who have completed at least 2½ years of the course in electrical engineering, or its equivalent, in one of the approved technical engineering schools listed in the War Department, may enlist in the Signal Enlisted Reserve Corps, and thereafter, upon presentation by the registrant to his local board of a certificate of such enlistment, such certificate shall be filed with the questionnaire and the registrant shall be placed in Class 5 on the ground that he is in the military service of the United States." Acknowledge.

CROWDER.

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Detailed Temporarily as Majors

By direction of the President the following-named officers, who hold the grade of major by reason of their having passed their junior military aviator or junior military aeronaut examination, are detailed in the Signal Corps temporarily as majors under the provision of the act of Congress approved July 24, 1917: Capts. Guy L. Gearhardt, John N. Reynolds, James L. Dunsworth, Delos C. Emmons, Arnold N. Krogstad, Thomas S. Bowen, Jack W. Heard, Claud K. Rhinehart, Tolbert F. Hardin, Arthur Boettcher, Bert M. Atkinson, Ira A. Rader, Leo G. Heffernan, Douglas B. Netherwood, Patrick Frissel, George H. Brett, Lewis H. Brereton, Edward L. Hoffman, Norman W. Peek, James R. Alfonte, Leslie MacDill, Paul L. Ferron, Lawrence S. Churchill, George E. A. Reinburg, Martin F. Scanlon, Davenport Johnson, Millard F. Harmon, jr., Thorne Deuel, jr., Shepler W. Fitz Gerald, Arthur R. Christie, John C. McDonnell, Roy S. Brown, John B. Brooks, John C. P. Bartholf, Harold M. Clark, Richard B. Barnitz, Harold S. Martin, Earl L. Canady, Clinton W. Russell, George E. Lovell, jr., George W. Krapf, Howard C. Davidson, Maxwell Kirby, Harvey B. S. Burwell, John W. Butts, Walter W. Wynne, William A. Robertson, Carl Spatz, Warren P. Jernigan, Benjamin G. Weir, Ralph Royce, William O. Ryan, Harry M. Brown, Sheldon H. Wheeler, Clinton W. Howard, Joseph T. McNarney, Edwin B. Lyon, Charles C. Benedict, John E. Rossell, Earl L. Naiden, Whitten J. East, Michael F. Davis, Hubert R. Harmon, Harry B. Anderson, Norman J. Boots, George Pulsifer, jr., Thomas J. Hanley, jr., Leo A. Walton, Ralph P. Cousins, Adlai H. Gilkeson, George E. Stratemeyer, and William B. Peebles.

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Appointments in the Officers' Reserve Corps

The following appointments in the Officers' Reserve Corps and National Army have been made in the Office of The Adjutant General. The officers whose names appear in this list, if they have not already done so, should telegraph acceptance of commissions to The Adjutant General, Washington, D. C. The telegrams should be signed with full name and rank.

To be captain, Aviation Section, Signal Reserve Corps:

Harold A. Wise, 301 Richmond Avenue, San Antonio, Tex.

To be first lieutenant, Aviation Section, Signal Reserve Corps:

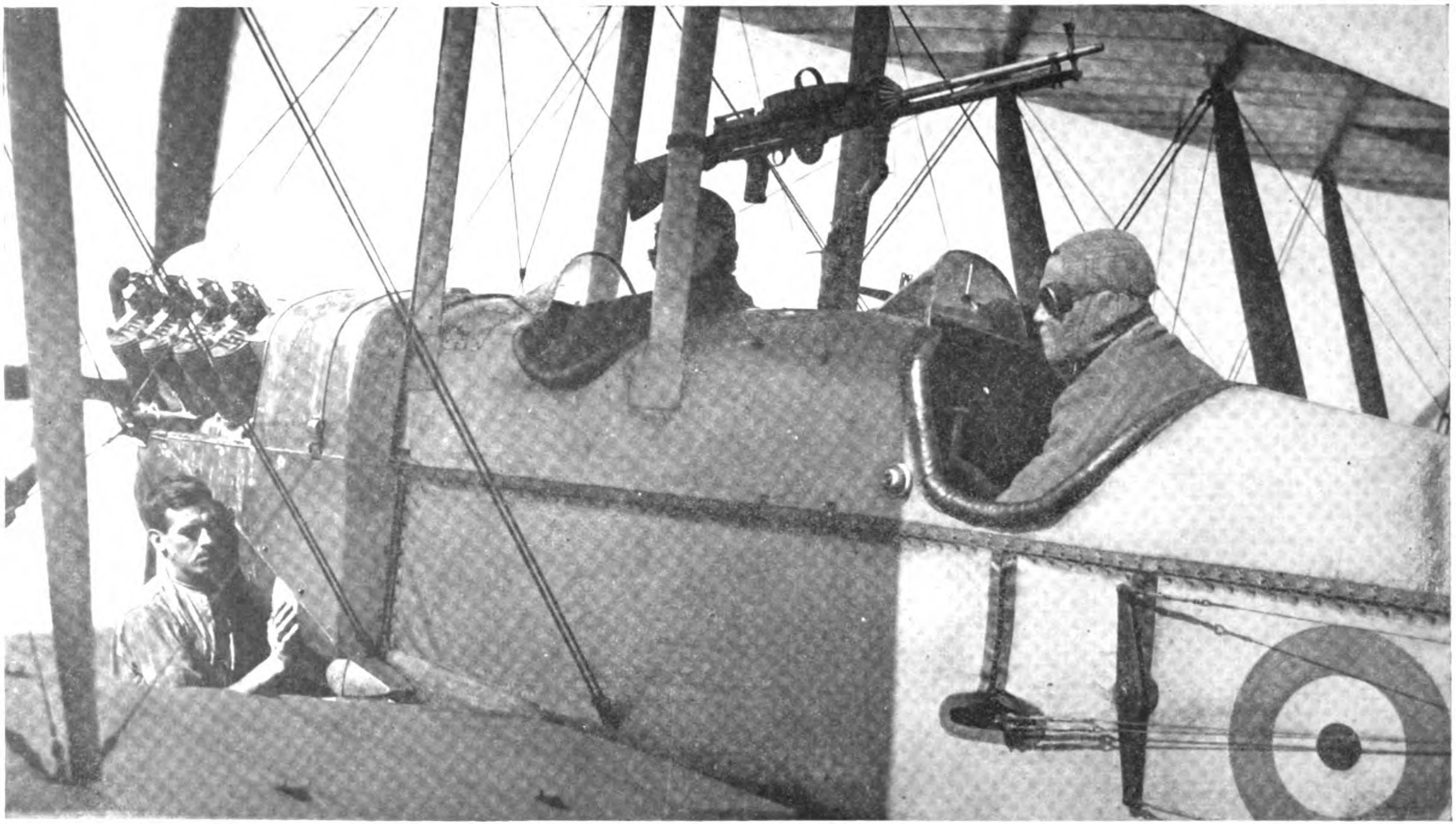
George W. Harvey, Camp Meade, Md.

To be second lieutenants, Aviation Section, Signal Reserve Corps:

Ohio State University, Columbus.—Sawnie R. Aldredge, Orlando B. Black and Thomas E. Nelson.

Georgia School of Technology, Atlanta.—Nelson H. Bedell, Walter K. Blanton, Fred J. Bolender, Ross Boothe, Robert H. Brown, Shermer D. Brunt, Clyde H. Carley, John F. Clark, Howard E. Cook, Harry S. Covington, Allan H. Crary, George A. Crocker, jr., Elmer F. Gegon, Donald M. Dey, Agnew T. Dice, jr., Rutherford Fleet, Nathan K. Gallinger, Edward W. Garnier, Rob R. George, Le Moyne R. Graham, Hubert G. Haller, Clyde M. Hamilton, Clark H. Hogan, Edward R. Kelly, Louis W. Kemp, Erick J. Kunkel, Bernard W. Lee, Raymond P. Luce, John B. McCormick, John E. McGraw, George B. Matthews, jr., Leland H. Merrill, Paul L. O'Reilly, James W. Rader, Max L. Rafeld, Erwin T. Ridgeway, Benjamin M. Schulein, Alfred C. Scott, Allan D. Shackleton, Fred M. Shields, Louis J. Shoemaker, James M. Slaughter, Herbert A. Stoddard, Gordon C. Thorne, Joseph T. Trotter, George B. Wallace, Charles B. Warner, Edward S. Winfree, Paul C. Yount.

To be first lieutenant, Aviation Section, Signal Corps, R. A. T. Edmund, A. Kruss, San Diego, Cal.

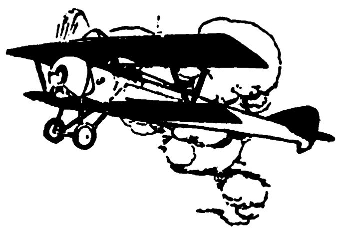


(C) Int. Film Svce.

The trim assembly of the modern war airplane may be noted from this view of a British two-seater, special interest attaching to the convenient suspension of the Lewis machine gun overhead and the air-cooled 8-cylinder V-motor with 4-blade propeller

How to Become an Aviator

The Eleventh Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By Henry Woodhouse

Author of "Text Book of Naval Aeronautics"

SUPPLEMENTAL to the description and definition of function of valves contained in the May issue, the student of this series will find a knowledge of valve setting and valve timing of value. Instruction in these two operations, as officially given for the Curtiss engine, follow:

Valve Setting—After grinding and cleaning, set the inlet valves at 0.010 clearance and the exhaust valves at 0.010 clearance. This setting should be done on each cylinder just after inlet valve has closed. If the stem is indented due to any cause, remove the valve and grind the stem end to a flat surface.

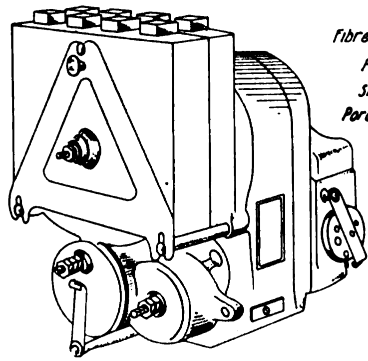
Valve Timing—After setting the clearance, turn the engine in the direction of rotation till the piston of No. 1 cylinder is 1/16 inch past top center. Then turn the camshaft in its direction of rotation till the exhause valve No. 1 cylinder has just closed. Put on the camshaft gear, being sure that the keyway of the gear lines up with the key in the camshaft.

Thus set and timed, the inlet valves will open 12 degrees past top center and close 40 degrees past bottom center; the exhaust valves will open 45 degrees before bottom center and close on top center.

As it is now purposed to consider ignition and its relation to the efficient operation of the aviation engine, these further practical suggestions on timing may well be included.

Magneto Timing—Turn the engine in the direction of rotation till the intake valve of No. 1 cylinder has closed; then turn the engine in the same direction till the piston of No. 1 cylinder is on top dead center; then turn the motor backward till the piston of No. 1 cylinder is ½ inch from top center. Turn the armature of the magneto in the direction of its rotation (it is the same as that of the crankshaft) till the distributor brush is on No. 1 segment with the breaker points just ready to open. Put on the magneto gear, using the same precaution as given for engaging the camshaft gear. This should bring the firing-time of all cylinders to 30 degrees before top center.

The spark advance lever should be in position of full advance during this whole operation. The gap between the breaker points should be 0.018 inch and that of the spark-plug points 0.023 inch.



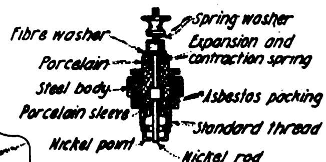


Figure 62-a

Figure 62-b

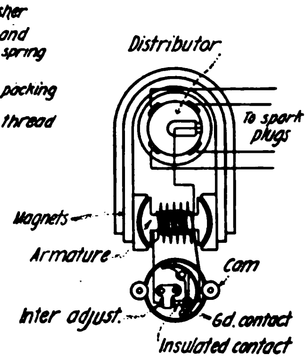


Figure 61—A high tension magneto

Figure 62a—Construction of spark plug
Figure 62b—General view of spark plug

Figure 63—Construction of the magneto

IGNITION

To set afire the compressed gas mixture in the cylinder at the proper time an electric spark is produced in the combustion chamber, through the medium of a spark plug the points of which offer a break in the ignition circuit, causing the current to jump the gap and spark. The essentials of an ignition system for aviation engines are, (a) a method of producing the current, (b) timing apparatus to regulate the sparking at the proper instant in each cylinder, (c) wiring and auxiliary devices to carry the generated current to the spark plug in the cylinder.

MAGNETO

Aviation motors are equipped with high-tension magnetos, i.e., those with a secondary winding of fine copper wire over the primary winding, as distinguished from the low-tension type with primary coil only. In the coarse wire winding, or primary (on top of which is the secondary winding of fine wire) a low-tension current is generated as the armature revolves between the ends of the magnets. This low-tension current then flows to the circuit breaker, where it is broken by the points operated by a cam. The current then goes to a condenser for storage until the points again close. Breaking the current creates a high-tension current which flows to the distributor and spark plugs.

Figure 61 shows the Berling high-tension magnetos, used on Curtiss engines and one of the best of the representative types; figure 63 shows the construction.

DISTRIBUTOR

The distributor is the device wherein both the primary and secondary currents generated by the magneto are collected by a brush and distributed to the proper cylinder at the proper time.

CONDENSER

Absorption of the self-induced current of the primary winding, thereby preventing it opposing the rapid fall of the primary current, is the function of the condenser.

CIRCUIT BREAKER

This device keeps the circuit closed except at the time of sparking.

SPARK PLUG

This device consists of an insulating member screwed into the cylinder and carrying the terminal electrodes across which the spark for ignition jumps. The secondary wire from the coil is attached to a terminal at the top of the central electrode. Details of construction of the spark plug are shown in figures 62a and 62b.

Spark plugs are screwed into the combustion chamber directly in the path of the incoming gases from the carbureter. On most aviation engines a double set of plugs is used, two to a cylinder, igniting the mixture at two different points and thereby gaining twenty-five per cent motor power at high speed.

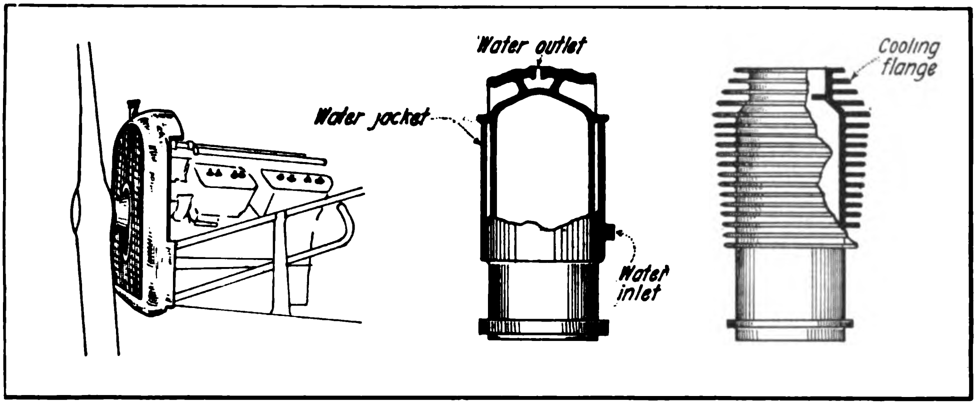


Figure 64—Radiator at front of fuselage   *Figure 65a—Water cooled cylinder*   *Figure 65b—Air cooled cylinder*

COOLING

The intense heat of the explosions in engine cylinders would heat the metal portions to a point where the lubricating oil would be burned and become useless and the piston rings expand and bind in the cylinder walls, if a means of cooling was not provided. There are two general systems of cooling: (a) water cooling; (b) air cooling.

WATER COOLING

This system consists of a circulation of water through jackets which surround the heated portion of the cylinder wall; a radiator, constructed of thin metal tubes with a large exposed surface area, wherein the water is cooled; and a means of keeping the water in circulation from the cylinder jackets to the radiator, and back again through the system.

Figure 64 illustrates one form of radiator, constructed at the front of the fuselage with provision for the propeller hub.

Figure 65-a is a view, partly in section, of a cylinder with water jacket cast integral.

The water is circulated either by a pump which is gear-driven from the motor, or it is automatically circulated by the thermo-syphon principle, which utilizes the tendency of heated water to rise.

When the airplane is at its angle of steepest climb maximum heating of the motor occurs. For this reason, radiators are constructed so the cells are not horizontal, but parallel to a tangent of the mean trajectory of climb.

AIR COOLING

Cooling flanges or metal fins are radiated from the cylinder walls in the air-cooled type of engine; to absorb the heat of the explosions and diffuse it in the rush of air. The cylinders are placed directly in the path of the propeller slip stream and often a powerful fan is used to increase the rate and degree of cooling.

Figure 65-b shows an air-cooled cylinder, partly in section.

The principal advantage of air cooling is reduction of weight through the elimination of the various parts of the water cooling system. Rotary radial cylinder types have proved practical with air cooling, but it is generally conceded that the water-cooled motor is best for long flights.

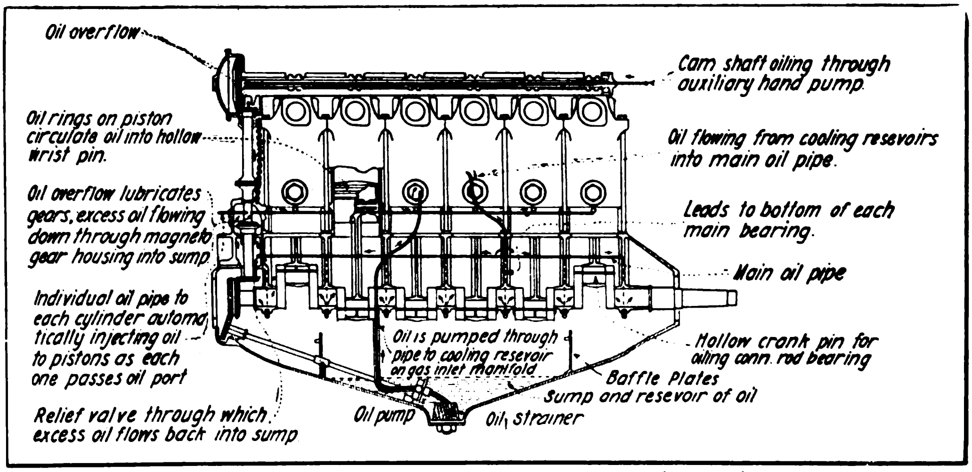


Figure 66—A modern oiling system for aviation engines

LUBRICATION

The necessity for providing some means of preventing excessive friction between swiftly moving parts is due to the heating which would result if a lubricant was not applied between them. The temperature of the aviation engine as a whole is an additional reason for insuring proper oiling of parts.

Two types of motor lubrication are in use:

(a) Splash lubrication—Oil is held in the sump, or reservoir at the bottom of the crankcase, and splashed on the moving parts by the revolutions of the crankshaft.

(b) Force-feed—Positive mechanical means deliver the oil under pressure to the various working parts of the engine.

Owing to the evolutions of the aeroplane in flight lubricating systems have been elaborated to deliver oil as needed to all working parts and to eliminate the possibility of flooding cylinders.

FORCE-FEED LUBRICATION

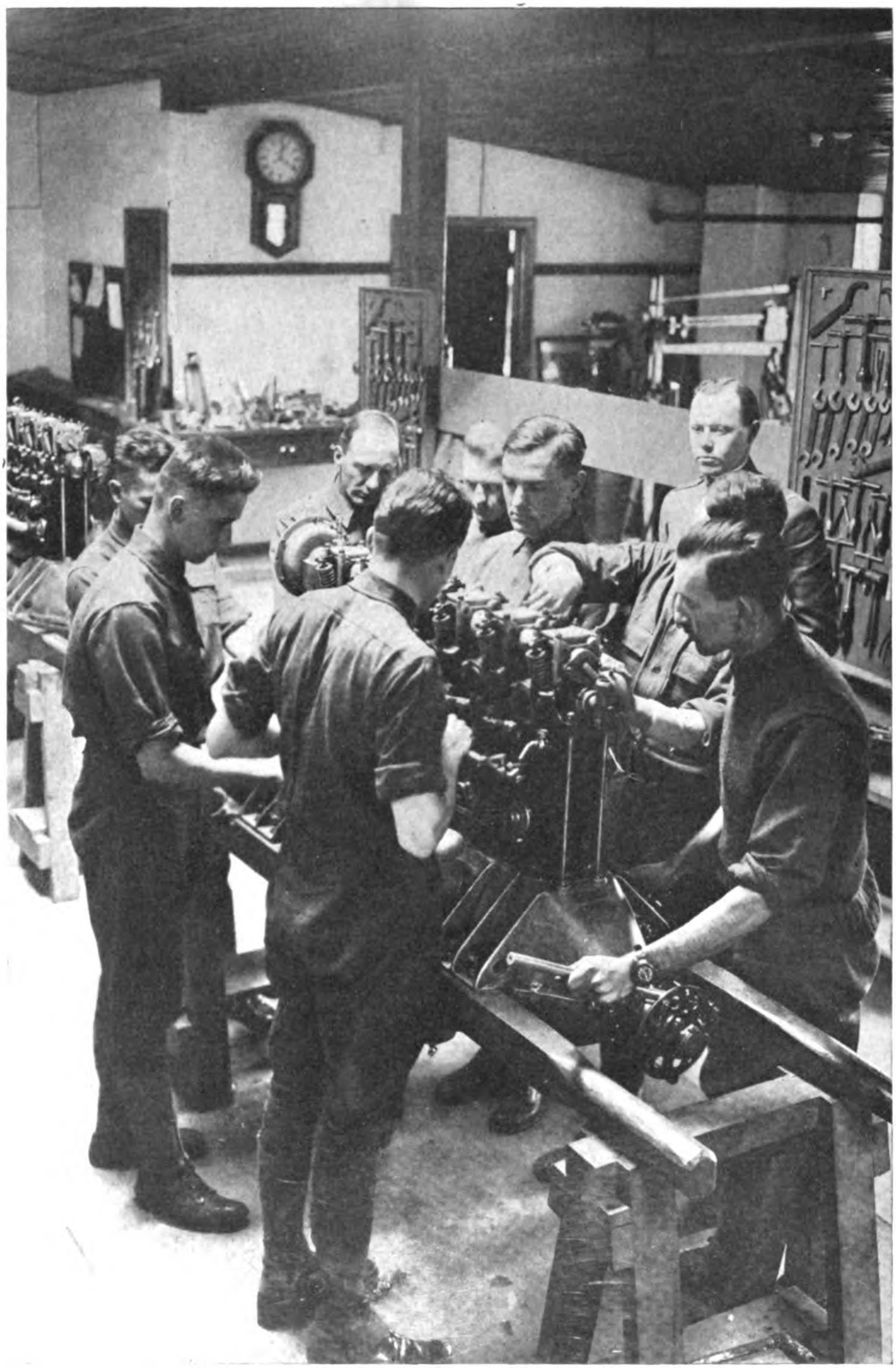
Figure 66 gives a clear illustration of a modern oiling system for aviation engines; in this instance, the Hall-Scott engine, selected as representative of the best practice in lubrication.

The crankshaft, connecting rods and all other parts within the crankcase and cylinders are lubricated directly or indirectly by a forced-feed oiling system. The cylinder walls and wrist-pins are lubricated by oil spray thrown from the lower end of the connecting rod bearings. The oil is drawn from the strainer located at the lowest portion of the crankcase, forced around the main intake manifold jacket. From here it is circulated to the main distributing pipe located along the lower left hand side of the upper portion of the crankcase. The oil is then forced directly to the lower side of the crankshaft, through holes drilled in each main bearing cup. Leakage from these main bearings is caught in scuppers placed upon the cheeks of the crankshaft furnishing oil under pressure to the connecting rod bearings.

A bi-pass located at the front end of the distributing oil pipe can be regulated to lessen or raise the pressure. By screwing the valve in, the pressure will raise and more oil will be forced to the bearings. By unscrewing, pressure is reduced and less oil is fed.

Independent of the above-mentioned system, a small, directly driven rotary oiler feeds oil to the base of each individual cylinder. The supply of oil is furnished by the main oil pump located in the lower half of the crankcase. A small sight-feed regulator controls the supply of oil from this oiler. This instrument is placed higher than the auxiliary oil distributor itself to enable the oil to drain by gravity feed to the oiler.

The oil sump plug is located at the lowest point of the crankcase. This is a trap for dirt, water and sediment and is removed by unscrewing. Oil is furnished mechanically to the camshaft housing under pressure through a small tube leading from the main distributing pipe at the propeller end of the engine directly into the end of the camshaft housing. The opposite end of this housing is amply relieved to allow the oil to rapidly flow down upon camshaft, magneto, pinion-shaft, and crankshaft gears, after which it returns to the lower crankcase. An outside overflow pipe is also provided to carry away the surplus oil.



(C) Comm. Pub. Info.

Student aviators of the Signal Corps, U. S. A., learning in the ground school how valves are adjusted and ignition timed on aeronautic motors

IMPORTANT DON'TS

Don't forget to inspect the motor thoroughly before starting.

Don't try to start without oil, water, or gasoline; all three are vital.

Don't forget to see that the radiator is full of water.

Don't get dirt or water into the oil.

Don't get dirt or water into the gasoline.

Don't forget to oil all exposed working parts.

Don't try to start without retarding the magneto; a serious accident may result.

Don't try to start without turning on the switch.

Don't start the motor with throttle wide open.

Don't run the motor idle too long; it is not only wasteful but harmful.

Don't forget to watch the lubrication; it is most essential.

Don't forget that the propeller is the business end of the motor; treat it with profound respect—especially when it is in motion.

Don't cut off the ignition suddenly when the motor is hot; allow it to idle for a few minutes at low speed before turning off the switch. This insures the forced circulation of the water till the cylinder walls have cooled considerably and also allows the valves to cool, preventing possible warping.

Don't fail to study the trouble chart before you molest a thing about the motor, if you have trouble.

Don't develop that destructive disease known as tinkeritis; when the motor is working all right, let it alone.

Don't forget a daily inspection of all bolts and nuts. Keep them well tightened.

Don't fail to stop your motor instantly upon detecting a knock, a grind, or other noise foreign to perfect operation. It may mean the difference between saving or ruining the motor.

THE TROUBLE CHART

Based on Curtiss engines, this chart has been prepared to outline in a simple manner the various troubles that interfere with the efficient action of aeronautical motors.

Defects that may develop are tabulated for ready reference, and opposite the part affected the various conditions are found under a heading that denotes the main trouble to which the others are contributing causes.

The various symptoms denoting the individual troubles outlined are given to facilitate their recognition in a positive manner. Brief note is also made of the remedies for the restoration of the defective part or condition.

It is apparent that a chart of this kind is intended merely as a guide, and it is a compilation of practically all the known troubles that may materialize in gas-engine operation. While most of the defects outlined are common enough to warrant suspicion, all will never exist in an engine at the same time; and it will be necessary to make a systematic search for such of those as do exist, and by the process of elimination locate the offending part.

To use the chart advantageously it is necessary to know and recognize easily one main trouble. For example, if the motor is skipping, look for possible troubles under the heading "Skipping." If the motor fails to develop power, the trouble will undoubtedly be found under "Lost Power and Overheating."

It is assumed in all cases that the trouble exists in the power plant or its components, and not in the auxiliary members of the ignition. In many instances, however, the seat of trouble will be traced to these latter members.

SKIPPING OR IRREGULAR OPERATION

PART AT FAULT	TROUBLE	EFFECT	REMEDY
Spark plug	Loose binding at post Leak in threads Defective gasket Cracked insulator Points too close Points too far apart Carbon deposit Plug too long	No spark Low compression Low compression Short-circuit No spark No spark No spark Pre-ignition	Tighten terminal Screw down tighter Replace with new plug Replace with new plug Set points apart Set points closer Clean off points and plug Change plug
Combustion chamber	Carbon deposit	Pre-ignition	Remove carbon
Piston head	Carbon deposit Crack or blowhole (rare)	Pre-ignition Pre-ignition	Remove carbon Replace with new
Valve head	Warped or pitted on seat	Poor mixture Low compression	True up in lathe and grind to seat Replace with new
Valve stem	Binds in guide sticks	Irregular valve action	Clean guide Straighten stem Oil
Valve spring	Weakened or broken	Irregular valve action	Replace with new
Exhaust valve seat	Scored or warped Dirty or covered with scale	Valve will not close Poor mixture Poor compression	Use reseat reamer Clean off and grind to seat
Exhaust valve-stem guide	Warped or carbonized Worn guide	Valve stem sticks Low compression Poor seating Poor mixture	Clean guide or new guide
Valve-stem clearance	Too little Too much	Valve will not shut Valve opens late and closes early	Set inlet gap 0.010 Set exh. gap 0.010
Camshaft bearing	Looseness or wear	Valves mistimed or valve lift short	Replace with new bushing
Cam	Worn contour	Valve lift short Valves mistimed	Replace with new camshaft
Timing gear	Not properly meshed Loose on shaft Worn or broken tooth	Valves mistimed Valves do not act	Time properly Fasten to shaft with key Replace with new gear
Cam-follower guide	Loose on engine base Lock pin sheared off Worn in bore	Oil leaks Poor valve action	Fasten securely New pin New guide or bushing
Cam follower	Loose in guide	Valves mistimed Oil leaks	Replace with new guide or bushing
Inlet valve	Closes late Opens early	Blowback in carbureter	Time properly
Inlet-valve seat	Warped or pitted Does not seat properly Carbon grain under seat	Blowback in carbureter Low compression	Use reseat reamer Clean off and grind to seat
Inlet-valve stem guide	Worn	Poor mixture Low compression	Bush or replace with new guide
Carbureter	Weak mixture	Blowback in carbureter	Adjust carbureter for richer mixture
Gas manifold pipe	Leak at joints Defective gasket Crack or blowhole	Poor mixture Poor mixture Poor mixture	Stop all leaks Replace with new Solder blowhole
Piston	Walls scored	Poor suction and leak of gas	Smooth up
Piston rings	Loss of spring Loose in grooves Worn or broken Slots in line	Poor suction and leak of gas Poor compression	Peen rings or replace with new Loosen rings on piston
Cylinder Wall	Scored by wristpin Scored by lack of oil	Poor suction and leak of gas Poor compression	Lap in cylinder Or new cylinder
Valve-spring collar key	Broken	Release spring No valve action	Replace with new key

LOST POWER AND OVERHEATING

Part at fault	Trouble	Effect	Remedy
Manifold connections	Poor mixture in one set of cylinders with good mixture in other set	Surging or pulsating	Tighten connections; put in new gaskets
Water-pipe joint	Loose Defective gasket	Loss of Water and overheating	Tighten bolts or replace with new connection
Spark plug '	Loose in threads Defective gasket	Poor compression and overheating	(See Spark Plug under "Skipping") Screw down tight Replace with new
Combustion chamber	Crack or blowhole Roughness Carbon deposit	Poor compression Pre-ignition Pre-ignition	Fill by welding or replace with new Smooth up Remove carbon
Valve-head	Warped, scored, or pitted Carbonized or covered with scale	Poor compression	True up in lathe and grind to seat Scrape off smooth with emery cloth
Valve seat	Warped or pitted Carbonized or covered with scale	Poor compression or blowback	Use reseat reamer Clean off and grind to seat
Piston rings	Loss of spring Loose in groove Worn or broken Slots in line	Poor suction, leak of gas, and over-heating Poor compression	Peen rings or replace with new Loosen rings on piston
Piston rings	Broken because too tight Insufficient opening	Scored cylinder walls. overheating in sump pan, and poor compression	Replace scored cylinder if groove is deep; use new rings
Wristpin	Loose Scored cylinder	Poor compression	Fasten securely Replace scored cylinder if groove is deep
Piston head	Carbon deposit Crack or blowhole (rare)	Pre-ignition Poor compression	Remove carbon Replace with new
Piston	Binds in cylinder Walls scored or worn out of round	Overheating	Lap off excess metal Replace with new
Cylinder wall	Scored Poor lubrication causes friction	Poor compression and overheating	Replace with new Lap in cylinder Repair oiling system
Camshaft Drive gear	Loose on shaft Not properly meshed Worn or broken teeth	Irregular valve action	Fasten to shaft Time properly Replace with new
Crankshaft	Scored or rough on journals Sprung	Overheating Overheating	Smooth up Straighten
Crankpin Bearings and main bearings	Adjusted too tight Defective oiling	Overheating	Adjust to running clearance Clean out oil holes
Oil sump	Insufficient oiling Poor oil Dirty oil	Overheating and burned-out bearings	Replenish supply Use best oil—Mobile "A" recommended Wash with kerosene Replace with new oil
Water space and water pipes	Clogged with sediment or scale	Overheating	Dissolve and remove foreign material
Radiator hose	Layer of hose obstructs opening	Overheating	Refit or replace with new
Water pump	Impeller loose on shaft Dirty Broken	Overheating	Fasten to shaft Clean Replace with new

NOISY OPERATION

Part at fault	Trouble	Effect	Remedy
Spark plug	Leakage	Hissing	Screw down tighter Replace with new
Cylinder wall	Scored	Knocking	Smooth up or replace with new
Manifold pipe joints	Leakage Defective gaskets	Sharp hissing	Tighten bolts Replace with new
Combustion chamber	Carbon deposit	Knocking	Remove carbon
Cylinder casting	Retaining bolts loose	Sharp metallic knock	Tighten bolts
Cam	Worn contour	Metallic knock	Replace with new
Piston head	Carbon deposit	Knock	Remove carbon
Wristpin	Loose in piston Worn	Dull metallic knock	Replace or bush
Connecting rod	Worn at wristpin or crankshaft Sideplay in piston	Distinct knock	Adjust or replace Scrape and fit and oil
Main crankshaft bearing	Loose Defective lubrication	Metallic knock Squeak	Fit caps close to shaft Clean out oil holes and oil
Connecting-rod bearings	Loose Excessive play Binding	Intermittent metallic knock Knock and squeak	Refit Reline
Connecting-rod bolts, main-bearing bolts	Loose Stripped threads	Sharp knock	Tighten Replace bolts
Lower half Crank-case bolts	Loose Stripped threads	Knock and rattle	Tighten New bolts
Water jacket	Covered with scale Clogged with dirt	Knock caused by overheating	Dissolve scale and flush out water space with water under pressure
Timing gears	Loose Worn or broken teeth Meshed too deeply	Metallic knock Rattle Grinding	Fasten to shaft Replace with new gear
Camshaft bearing	Loose or worn	Slight knock	Replace with new
Inlet-valve seat	Warped or pitted Dirty	Rattle Poor compression Blowback	Use reseat reamer Clean off and grind to seat
Inlet-valve spring	Weak or broken	Blowback in carbureter	Replace with new
Inlet valve	Closes late Opens early	Blowback in carbureter	Time properly
Valve-stem guide	Worn or loose	Rattle or click	Replace with new guide
Cam-follower guide	Loose	Rattle or click	Replace with new guide
Valve-stem clearance	Too much Too little	Click Blowback in carbureter	Set inlet gap 0.010 Set exh. gap 0.010
Push-rod retention stirrups	Nuts loose	Rattle Blowback in carbureter	Tighten nuts
Crank-case gaskets	Leak	Oil leak	Tighten bolts Replace with new
Cylinder or piston	No oil Poor oil	Grinding and sharp knock	Repair oil system Use best oil
Piston	Binding in cylinder Worn oval causing side slap	Grind or dull squeak Dull hammer	Lap off excess metal Replace with new
Oil sump	Insufficient oil Poor oil	Grind and squeak in all bearings	Replenish with best oil
Piston rings	Defective oiling	Squeak, hiss, grind	Replace with new ring Repair oil system
Crankshaft	Defective oiling	Squeak	Clean out oil holes Use best oil Repair oil system
Engine base	Loose on frame	Dull pound	Tighten bolts

In the twelfth article of this series, which will appear in the July issue, rotary engines and V-shaped multi-cylinder aviation motors will be considered.

Aviation News

Steel Airplane Traps for Allied Aviators

At Zeebrugge, the German naval and aerial base on the Belgian coast, the Germans have adopted a new method of catching hostile airmen.

Toward evening, says the "Telegraaf" (Amsterdam) frontier correspondent, the Germans send up twenty captive balloons, without crews and attached to electrified steel cables. The electric barrier is said to constitute a menace to all airmen coming in contact with it.

The Germans, it is added, have also manufactured a new and improved type of airplane. It is fitted with three propellers, one being so arranged it can keep the airplane stationary above a certain point for a few minutes, thus permitting the bomb thrower to aim with greater accuracy.

New Heads of Aircraft Boards

Left—John D. Ryan, "the copper king," who has been appointed director of aircraft production for the Army.

Right—Brig.-Gen. Wm. L. Kenly who will direct the newly created Division of Military Aeronautics. It will be responsible for the training of aviators and will direct the air forces. This work has heretofore been under the direction of the Signal Corps.

4,500 Men to be Drafted for Aviation

Provost Marshal General Crowder has announced that 4,500 draft registrants will be called to equip themselves to assist in the maintenance of the Air Fleet. The call affects Illinois, Minnesota, Iowa and Indiana, and the selected men will be given a thorough training course in woodworking and gas engine operation and repair. Fourteen educational institutions have been selected by the government.

The voluntary induction system will be tried, but where the State fails to produce its quota, local boards will be directed to conscript enough men to fill it. It is specified that the registrant must have had a grammar school education.

The schools and quotas which each State is directed to send follows:—

Minnesota—Three hundred men to Carnegie School of Technology, 500 to University of Cincinnati, 500 to University of Minnesota, 180 to Pennsylvania College, 320 to University of Pittsburgh.

Illinois—One hundred men to University of Chicago, 200 to Lewis Institute, Chicago; 100 to Northwestern University, Evanston, Ill.; 300 to Bradley Polytechnic Institute, Peoria, Ill.

Iowa—One hundred to New York University, 400 to University of Wisconsin, 500 to Rahe Automobile and Tractor School, Kansas City, Mo.; 500 to Sweeney Auto School, Kansas City, Mo.

Indiana—Five hundred to Purdue University, Lafayette, Ind.

Will Send No More Untrained Aviators to France

E. Percy Noel, of the New York Globe, is authority for the statement that from now on practically no pupils or pilots will be sent to France to begin or complete their training. Already one advance school, which was partially borrowed from the French, has been abandoned by the Americans. Elementary and advanced schools developed from a French nucleus or wholly created in France by the Americans will become aviation reserve depots for trained pilots.

These pilots arriving from home and also squadrons of enlisted men will have equipment and opportunity for practice so as to be tuned up to top pitch flying ability until ordered to the front. Pupils from ground schools and also military pilots have been sent to France in the past because of the lack of facility principally in the matter of airplanes and instructors for their training at home. Until the latest types of the fastest machines could be reproduced in America instruction was impossible.

Seaplanes Destroy U-Boats in Face of Odds

Under a heavy attack from three German submarines and three German destroyers, a British seaplane recently persisted in her efforts against another enemy U-boat, and succeeded in sinking it before being damaged by the fire of the other enemy warships, says a recent press dispatch.

The seaplane was on patrol duty at 8:30 o'clock in the morning when a submarine was sighted on the surface with a man standing forward by the gun. Increasing her speed, the seaplane dropped to an altitude of 600 feet and released a bomb. As she swooped around to repeat the attack, a shell from the U-boat burst in the air fifty feet from the propeller. It was seen that the bomb had made a direct hit, a big rent being visible in the deck of the submarine. Just then, out of the mist ahead appeared three more enemy submarines, followed closely by three destroyers.

All six vessels maintained a hot fire against the seaplane, which succeeded however in dropping a second bomb near the disabled U-boat. It exploded fifteen feet ahead of the bow of the submarine. The whole craft shook and then sank quickly in a pool of oil, bubbles and wreckage. The seaplane, having no more bombs, and as the destroyers were coming nearer, returned to its base.

Seaplanes also have accounted for three other submarines. In one case two large seaplanes attacked a submarine on the surface and with two Germans standing on the conning tower. One plane dropped a bomb to the starboard of the U-boat, while the other placed one squarely in front of the conning tower. The explosion of the second bomb was followed by several explosions within the submarine, which disappeared.

Diving from a height of 4,000 feet to 1,200 feet, another seaplane dropped a depth charge on the spot where a submarine had disappeared. When the water subsided, the shape of the submarine could still be seen below the surface and a second bomb was dropped, "after which the ship disappeared."

An enemy submarine about two hundred feet in length and with two periscopes was sighted by a seaplane on patrol duty. The seaplane descended 3,300 feet to a height of 800 feet and dropped two bombs as the Germans submerged. One of the bombs made a direct hit just behind the conning tower. The submarine turned upside down and sank. Oil and wreckage later came to the surface.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XIV

By Elmer E. Bucher

Director of Instruction Marconi Institute

EDITOR'S NOTE—This is the fourteenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

GENERAL CONSIDERATION

(1) We have shown the fundamental radio frequency circuits of the transmitter and receiver and the necessity of establishing resonance between the transmitter and receiver to establish communication.

(2) Because aerials rarely possess identical values of inductance and capacity, the antenna at the receiving station must be provided with a **variable series inductance** and **variable series capacity.*** These permit the receiving aerial to be tuned to wave lengths above and below the fundamental or natural wave length.

(3) An **increase of inductance** at the base of the aerial places it in condition to respond to long wave lengths, and the **insertion of a series capacity** makes it responsive to waves below its natural wave length.

(4) In some cases both series inductance and capacity are employed simultaneously to obtain a greater degree of selectivity, that is, to permit discrimination between interfering stations. The natural decrement of the aerial circuit is thus changed to a favorable value.

(5) The **secondary circuit** of the receiving system contains a **secondary variable inductance coil, a shunt variable condenser,** an **oscillation detector** and a current translator—usually a **head telephone,** the **tuning elements** being the secondary coil and the shunt condenser.

(6) The antenna system of a receiving station comprises:
(1) an aerial tuning inductance popularly known as the "loading coil";
(2) a primary inductance to transfer energy to the secondary circuit;
(3) a short wave series condenser.

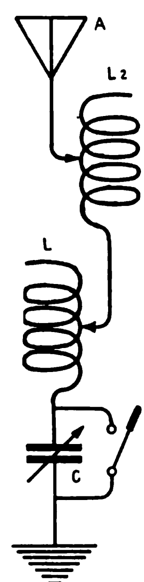


Figure 121.—Showing the correct position of the tuning elements in the antenna system of a receiving station. L-2 is the aerial tuning inductance; L-1, the primary winding of a tuning transformer, and C a short wave variable condenser. The function of L-2 is to tune the antenna system to waves above its natural wave length; of L, to transfer energy to a secondary coil (not shown); of C, to tune the antenna system to waves shorter than the natural wave length of the aerial.

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* A shunt variable inductance or shunt variable capacity also may be employed for tuning purposes.

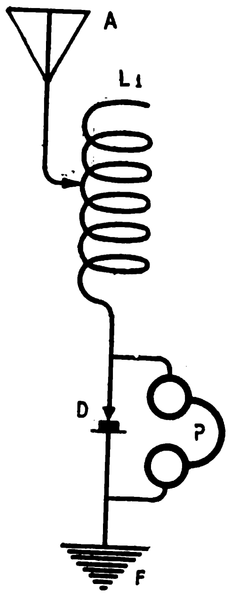


Figure 122

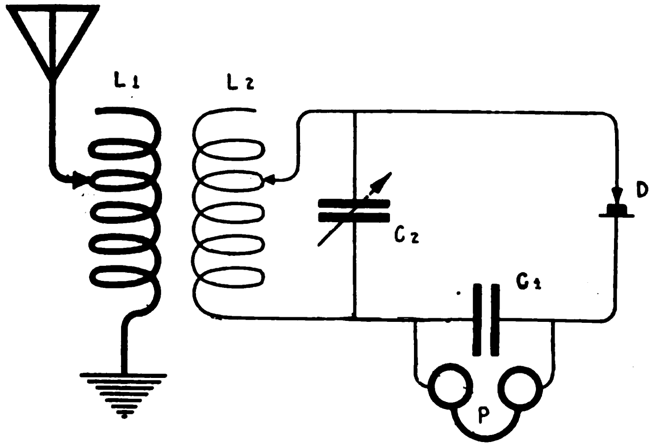


Figure 123

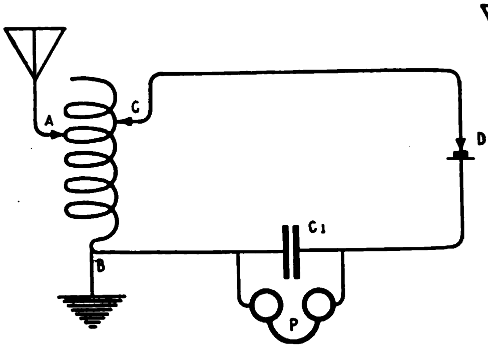


Figure 124

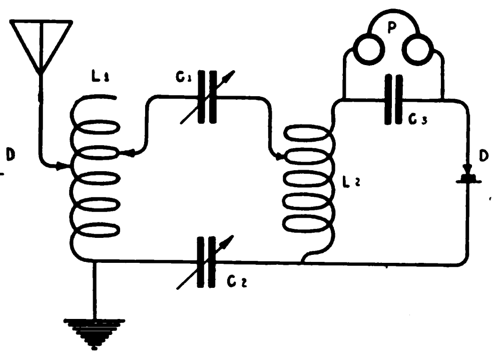


Figure 125

OBJECT OF THE DIAGRAMS

(1) Figure 122. To outline the circuits of a simple wireless receiver.
(2) Figure 123. To show the circuits of an inductively coupled receiver.
(3) Figure 124. To show the circuits of a direct or conductively coupled receiver.
(4) Figure 125. To show the circuits of an electrostatically coupled receiver.

PRINCIPLE

An oscillation detector may be connected directly in series with the antenna system, but better results are generally obtained by placing it in a local oscillation circuit which is coupled inductively, conductively, or electrostatically to the antenna system.

DESCRIPTION OF THE DRAWINGS

In figure 122, crystal rectifier D connected in series with the antenna circuit A, L-1, E, is shunted by the head telephone P. This is known as the **plain aerial connection.**

In figure 123, the primary winding of the receiving transformer is indicated at L-1, the secondary winding at L-2, the shunt variable condenser at C-2, the crystal rectifier at D, the head telephone at P, and the shunt condenser at C-1. Coils L-1 and L-2 are in variable inductive relation.

In figure 124, a single coil is employed to transfer the incoming oscillations from the antenna circuit to the local detector circuit. The turns A to B include those of the primary circuit. The turns B to C are those of the secondary circuit. The complete circuit comprises the crystal rectifier D, the head telephone P, and the shunt condenser C-1.

In figure 125, the primary winding of the receiving transformer is indicated at L-1, the secondary winding at L-2 in series with which are the condensers C-1 and C-2. The detector circuit comprises the coil L-2, the condenser C-3, the telephone P, and the detector D. L-1 and L-2 are said to be electrostatically coupled through condensers C-1 and C-2.

OPERATION

The apparatus in figure 122 functions as follows: A train of electromagnetic waves radiated by the transmitter induces a radio frequency alternating current in the aerial circuit A, L-1, E. This current will flow freely through the crystal in one direction, but will be opposed in the opposite direction. In one direction, let us say, the current passes from the earth upward through the crystal and then places a charge on the aerial wires, but the return current is opposed; hence the rectified oscillations for each spark of the transmitter accumulate a charge on the antenna wires which at the condenser C-2 through the circuit D, P, C-1 being oscillatory is rectified by D and a charge for each group of oscillations accumulates in the condenser C-1. kind does not possess the tuning qualities of the coupled circuits.

The apparatus shown in figure 123 functions as follows: The radio frequency current flowing through the coil L-1 induces a current of similar frequency in coil L-2, resonance being established by the shunt condenser C-2. Thus the oscillations in the complete receiving system attain their maximum amplitude. The discharge of the condenser C-2 through the circuit D, P, C-1 being oscillatory is rectified by D and a charge for each group of oscillations accumulates in the condenser C-1. C-1 then discharges through the head telephone P in one direction. Resonance may be established between the primary and secondary circuits without the use of the shunt variable condenser C-2, the necessary capacity being found in the distributed capacity between the turns of the secondary coil. A circuit of this kind gives more favorable results with oscillation detectors which depend for their action upon the value of the voltage impressed, than a circuit in which a shunt variable condenser of considerable capacity is employed.

In the apparatus shown in figure 124, the radio frequency current flowing through the turns A to B sets up a magnetic field which cuts through the remaining turns B to C, and a current of similar frequency is impressed across crystal detector D, where it is rectified. A charge accumulates in C-1 over the duration of a group of oscillations and C-1 discharges into the head telephone P.

The apparatus shown in figure 125 is said to operate as follows: Radio frequency current flowing through the coil L-1 is transferred through the coil L-2 by condensers C-1 and C-2, the coupling between coils L-1 and L-2 varying as the capacity of the condensers.

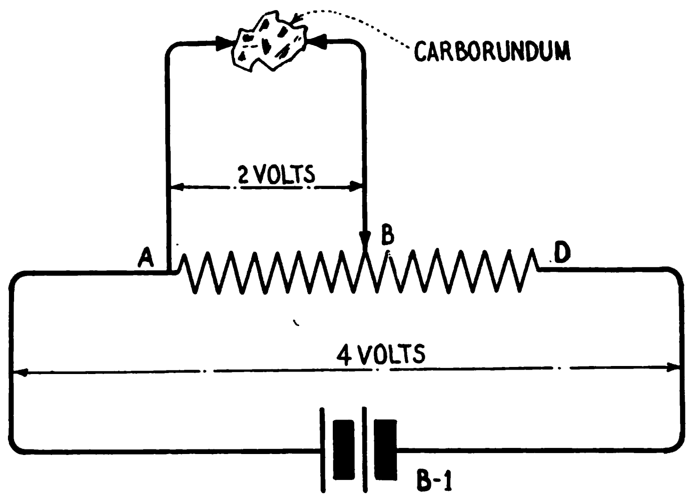


Figure 126

OBJECT OF THE DIAGRAM

To show the use of a potentiometer and battery in connection with crystal rectifiers.

PRINCIPLE

By applying a local current to a crystal rectifier, advantage can be taken of its non-uniform conducting properties to make a sensitive oscillation detector.

DESCRIPTION OF THE APPARATUS

A battery, B-1, of 2 to 4 volts is shunted by a potentiometer A, D, of 300 to 500 ohms resistance. A variable connection, B, can be placed at any point upon the resistance coil A, D. If the potential across A, D, for example, is 4 volts, the potential across the carborundum rectifier may be reduced to any desired lower value as the contact B is moved in the direction of A. Moved in the opposite direction, the potential applied across the carborundum crystal increases to the maximum E. M. F. of the battery. Thus very close regulation of the applied voltage can be obtained.

SPECIAL REMARKS

(1) Potentiometers may be made of **German silver wire** wound on an insulating base, over which moves a variable contact; or a sliding contact may make connection with a semi-circular **graphite strip.** Occasionally potentiometers are made of **carbon buttons** which are connected in series and successively cut in the circuit by a multi-point switch. Some potentiometers are wound in the form of a coil of resistance wire, taps being brought out at intervals to the terminals of a multi-point switch.

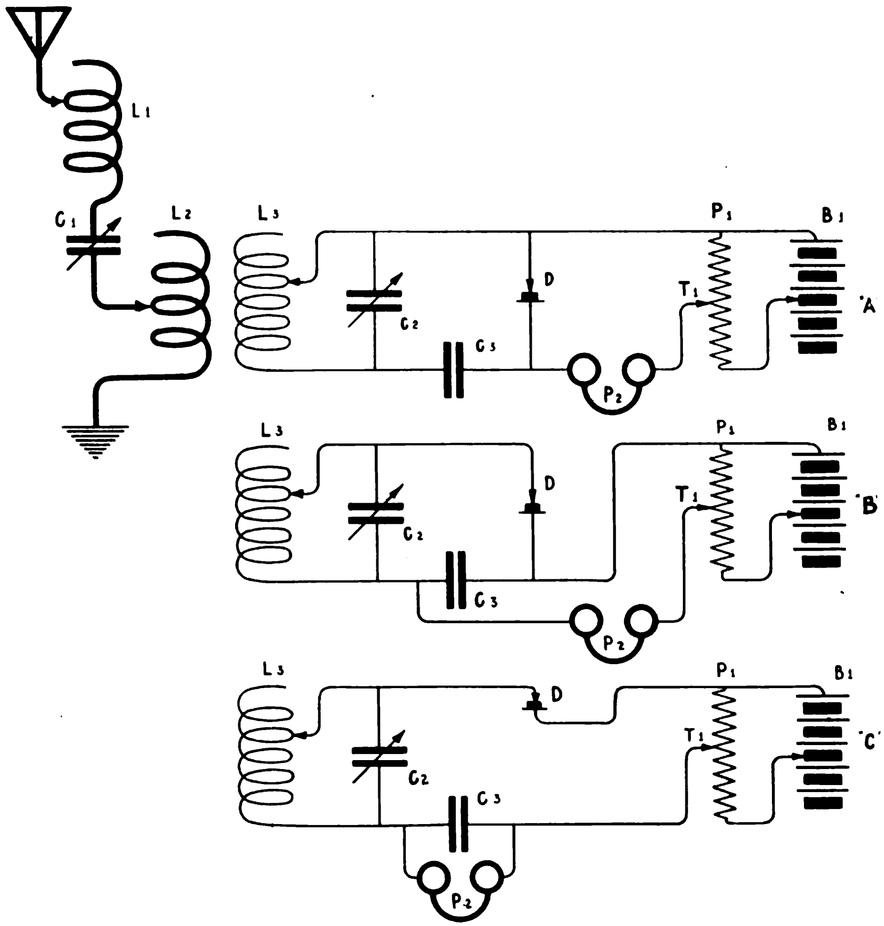


Figure 127, *a, b, c*

OBJECT OF THE DIAGRAM

To show the fundamental circuits of the inductively coupled receiving tuner connected to a carborundum rectifier, and to outline the various modes of connecting the potentiometer and battery to the crystal.

PRINCIPLE

The application of a local E. M. F. to a carborundum crystal permits advantage to be taken of its non-uniform conductivity, making it a more sensitive detector of the passage of radio frequency currents.

DESCRIPTION OF THE DRAWING

In figure 127a the **aerial tuning inductance** is represented at L-1, the **short wave variable condenser** at C-1, the **primary winding** of the receiving transformer at L-2. The **secondary winding** is indicated at L-3, the **shunt variable condenser** at C-2, a **crystal rectifier** at D, and the **stopping or blocking condenser** at C-3. A **potentiometer** is indicated at P-1 shunting the battery B-1. The **head telephone** is shown at P-2 ,having the variable contact T-1 which may be moved back and forth upon the potentiometer.

In figure 127b, the telephones, potentiometer, and battery are connected around the condenser C-3, current from B-1 flowing through P-2 through coil L-3, through the crystal D, to the opposite pole of the battery.

In figure 127c, the potentiometer, crystal, head telephones, and the coil L-3 are connected in series.

OPERATION

The manipulation of the potentiometer for the most sensitive adjustment of the crystal is practically the same in all cases, the sliding contact T-1 being moved back and forth upon P-1 until the loudest signals are obtained. It is necessary that the current from the battery B-1 flow in a definite direction through the crystal D, and if the battery is not provided with a reversing switch, the operator must either turn the crystal D about in its holder or he must reverse the connections of the battery.

SPECIAL REMARKS

(1) The potentiometer P-1 should have at least 400 ohms resistance, as it is shunted to the battery at all times; if of lower value it would exhaust the battery in a short time.

(2) The circuit of figure 127a is the one employed during the period 1906 to 1912 in connection with the carborundum rectifier. The circuit of figure 127b was later adopted by commercial operating companies in the United States. The circuit of figure 127c is fundamentally that employed in tuners designed by the English Marconi Company.

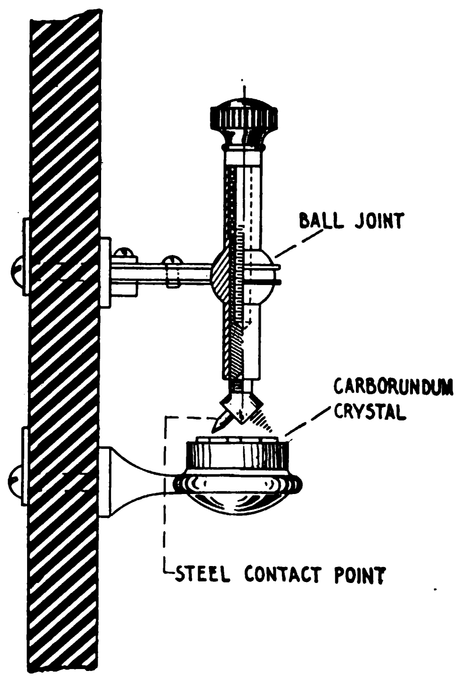


Figure 128.—Showing the construction of the carborundum crystal detector of the American Marconi Company. A number of carborundum crystals are embedded in a retaining cup which extends vertically from the panel of a receiving set. A steel contact point, usually a phonograph needle, is mounted on an adjustment rod which in turn is supported by a ball joint so that the steel contact point can be oriented about the several crystals. A fine wire contact point permits the use of a crystal rectifier, such as cerusite, which requires light contact pressure. In practical adjustment, the operator merely shifts the position of the steel contact point on the crystal simultaneously adjusting the potentiometer until the loudest signals from a given station are obtained.

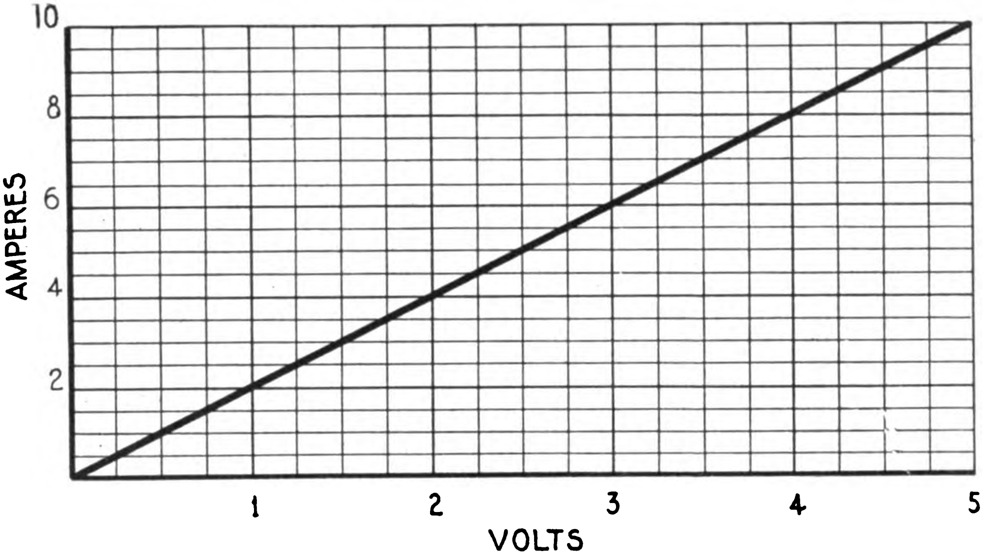


Figure 129.—Showing the current-voltage characteristic of an ordinary resistance. According to Ohm's law, if the E.M. F. of any circuit be increased, the flow of current will be increased in the same ratio provided the resistance of the circuit does not change on account of the rise of temperature. If a direct E. M. F. is applied to a circuit of given resistance and the voltage is progressively increased, the corresponding reading of the ammeter in series with the circuit being noted, the data plotted on cross-section paper will give the straight line of this figure. Thus, one volt corresponds to a current of two amperes, two volts to a current of four amperes, and three volts to a current of six amperes, and so on. Rectifiers such as carborundum, employed for detection of oscillations in radio telegraphy do not obey Ohm's law. In other words, they do not possess a steady or uniform resistance.

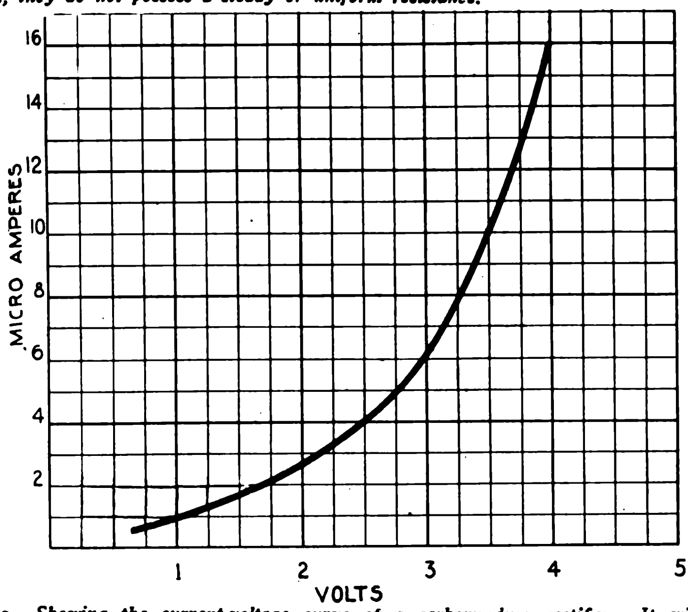


Figure 130.—Showing the current-voltage curve of a carborundum rectifier. It will be seen that an increase of voltage in the lower part of the curve does not result in a uniform increase of current, but after the applied potential reaches a value of three volts, a slight increase in voltage results in a much greater increase of current than is obtained in the first part of the curve. This figure shows the lower bend of the characteristic curve and part of the vertical slope. If the plotting was continued, the upper end of the curve would flatten. If the curve of figure 130 were applied to the circuit of figures 127a, b and c, the operation of the circuits under the influence of an impressed radio frequency current would be as follows. For example, if the E. M. F. of the battery current impressed across the crystal D, is three volts, we note from figure 130 that the corresponding current is six microamperes. Now, let the alternating current of radio frequency (of the incoming signal) have a potential of one volt and let it be superposed upon the battery flowing through the crystal. Then, in one direction, the voltages will add, and the total E. M. F. will be four volts. From the curve, the corresponding current is found to be 16 microamperes. But when the impressed E. M. F. flows in the opposite direction, it opposes that of the local battery, and the resulting E. M. F. is two volts. Reading from the curve, we obtain a current reading of 2.5 microamperes. It will thus be seen, under the influence of the first cycle of the impressed E. M. F., that the current of the local battery circuit varies between 2.5 and 16 microamperes. The sound produced in the head telephone, however, will be proportional to the difference between the initial current (about six microamperes) and the average value of current flowing when an external oscillating voltage is applied. This is explained more clearly in the following figure.

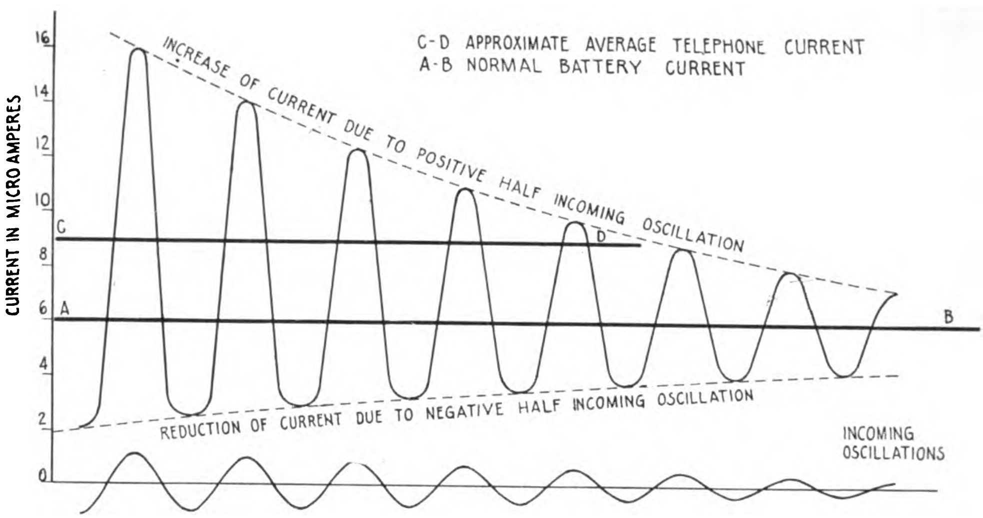


Figure 131.—Curve showing the fluctuations of the local battery current flowing through the carborundum rectifier during the reception of signals. As stated in connection with figure 130, the normal current flowing through the head telephone when no oscillating E. M. F. is applied is six microamperes, the voltage of the battery being three volts. But when an oscillating E. M. F. of one volt is added to that of the local battery, the maximum amplitude of the battery current for the initial cycle of the incoming oscillations is 16 microamperes, and of course, successive maxima will be of lesser amplitude according to the decay of the incoming wave train. The successive reductions of the normal battery current shown below the line A, B, are relatively small because as is clear from figure 130, for all voltages less than three volts the current (in microamperes) flowing through the local circuit is relatively small. The result of this is seen to be a series of a positive maxima of gradually decreasing amplitude which occur at such frequency that the telephone diaphragm cannot respond to them individually, but they produce an average effect upon the receiver, that is, the movement of the telephone diaphragm follows that of a decaying D.C. E.M.F. We may consider the average current in the case of figure 127a to be 9 microamperes and the difference between the normal current 6 microamperes, and the average current 9 amperes or 3.5 microamperes, to be the current which produces audible sound in the receiving telephone. We must keep in mind that this decaying E. M. F. rises to some value and then slowly dies out. The effect of a single group of incoming oscillations upon the telephone receiver is seen to be an increase of current in one direction during the reception of a complete train of oscillations.

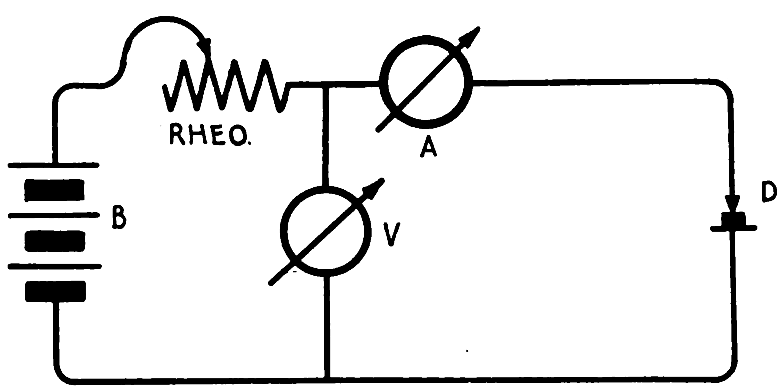


Figure 132.—Showing the apparatus for determining the current voltage characteristic of the carborundum rectifier. The battery B with the series rheostat or a potentiometer is shunted by the volt-meter V. A milliammeter or microammeter A is connected in series with the crystal D. The voltage of B is progressively increased as may be noted by observing the deflections of V. The corresponding current reading is taken from the meter A. The data thus obtained can be plotted on cross section paper in the form of a curve such as is shown in figure 130.

Americans Under Fire at Sea

The Torpedoing of the Actaeon

By G. A. Jensen

Operator G. A. Jensen

OUR third encounter with submarines within a month which ended disastrously for us occurred two days after leaving France for the United States. We left Bordeaux in ballast and when about thirty miles off shore a hydroplane flew overhead and alighted in the water ahead of us. The observer reported a submarine about twenty miles ahead and warned us to give it a wide berth; which we did with pleasure.

Two days later, when about 400 miles from France, we were torpedoed shortly after 7 p. m., without warning of any kind. At the time we thought we were practically out of the real danger zone. We later found we had a submarine on each side.

The torpedo struck in the after part of the ship and sent things flying in all directions in the wireless room.

I was on watch at the time, having relieved the junior operator J. A. Atkins, at 6 p. m.

The ship's dynamo was put out of commission by the concussion. Realizing our main set was useless, we started testing our emergency set to send the distress call, as we were without convoy and alone. The ship started sinking rapidly and all hands were ordered to take to the boats immediately. As the last boat was about to leave I went back on deck and slid down the rope falls, together with the two men who lowered the boat. We were but a short distance from the ship when a submarine appeared out of the briny deep and started toward us; while approaching he Morsed with a light to another submarine some distance away. His wireless masts were stepped and his guns trained on us. About twelve of the crew were on deck with automatics in their hands.

Once within hailing distance they ordered the nearest boat to come alongside. Being true apostles of the safety-first propaganda, the boats started off in different directions bound for nowhere in particular, their object being solely to get as far away from those submarines in as little time as possible.

When torpedoed, we were about 150 miles from the nearest land, in very threatening weather. The following morning found us battling with a gale which continued until after we were picked up. After 36 hours, we sighted land. We thought it was Portugal, but it proved to be Spain. Shortly afterward we sighted a small Spanish coasting steamer which we signaled. We were taken aboard, half frozen and nearly famished.

This vessel landed us in a Spanish port the following day, where we were taken in charge by the American Consul, given clothes and later sent back to the United States on a Spanish passenger ship.

Unfortunately, all of our boats did not fare as well as we did, some of the crew dying from exposure and thirst before being picked up. One boat containing 19 Navy gunners and 5 of our crew has not yet been accounted for.

When the Alamance Went Under

BY HARVEY R. BUTT

OPERATOR HARVEY R. BUTT

THERE is a law that for every effect there must be a cause. In the case of the Alamance it may have been the second mate who took the skipper's black kitten ashore one night and suggested with the aid of his shoe that kitty disappear up a dark alley. Kitty never returned. Again, it may have been the numerous improvements made in the rooms of the officers (including Sparks'), and that superstition among mariners that such innovations never do the ship any good.

Whatever the cause, the effects may be traced through a chain of minor mishaps to the climax: the torpedoing of the S. S. Alamance on February 5th, 1918, just off the Irish coast.

In port, considerable difficulty was experienced in taking fuel oil aboard, too, and in the middle of the trip the cabin boy nearly died of heart disease while just outside of the war zone our steering gear carried away and we had to heave to for a few hours till the gear was repaired.

We were in a convoy of 25 ships, escorted by a large British cruiser. At the beginning of the trip we were next to the last ship in the second line, but just before we entered the war zone the positions of several ships were changed, and we were then the second ship in the third line.

On the morning of the 5th we sighted the coasts of Scotland and Ireland, and during the day entered the Irish Sea. Having come so far safely and being then inside, everyone felt secure and gave no more thought to Fritz and his highly explosive strafing.

Lest some wiseacre nod his head knowingly at this juncture, I will add that the convoy was still in formation and was zigzaging. We were surrounded by destroyers, light cruisers, and trawlers, also we were highly "cauliflowered" in the latest American fashion. We carried four-inch guns mounted fore and aft, with a gun crew to man them.

I was sitting in the radio cabin, writing, when I heard a tremendous roar and felt the ship give a lurch to port. I lost no time moving out of the room. I remember being thankful that the door had not jammed. I ran to the next door aft, which was the entrance to my room; it would not open so I ran back to the radio cabin and climbed through a cubbyhole which connected with my room. It didn't take long for me to get into sweaters and coats and get on deck again and up to the bridge. Finding no one there I returned to the main deck, just in time to see one of the boats smashed up, spilling several men into the water. Going up to the lower bridge I found the captain; he told me that there was no need of getting out an S O S. Both of the starboard boats had been smashed by the seas but the two on the port side were intact, although the torpedo hit almost directly under one of them. I hopped into one of these lifeboats and helped to pull away from the ship. We started for a light cruiser which had stopped for us, but on sighting two men in the water a little distance from us we turned and pulled over, but were beaten to them by a small boat sent out from the cruiser. A trawler came alongside then and we climbed aboard, setting the lifeboat adrift. The two men picked up in the water were also put aboard the trawler and proved to be our second mate and a seaman.

While they were changing their clothes I went out on deck and watched the good ship sinking, slowly at first and then faster and faster, till the stern was completely under. She stood on end then for a minute, and dropped out of sight.

When the men had changed their clothes for dry ones given them by the crew of the trawler, we were transferred to the cruiser. There we found the rest of the officers and crew. The officers, including myself, were given the use of the officers' wardroom. A supper of canned willie and hardtack with tea was served, sugar and butter being included. During the night hot whiskies were served regularly to those who wanted them. Next morning a breakfast of fried canned willie and ham, hardtack, butter and sugar was served. Just before dinner we ran alongside the landing stage of Liverpool and were landed. The ship's company agent put us up at various hotels after the alien officers had gone through their usual red tape, and for nine days we lived on fish and chips, without sugar and only a little butter for the war bread.

It was a very happy party that stepped ashore in New York.

On the Schuylkill, Hun Victim

By D. C. Smith

Operator D. C. Smith

THE American steamer Schuylkill, owned by the Greek Line, left New York bound for Piræus, Greece, on the 13th of October. Speaking for myself and a few others of the crew, we would have been better satisfied if the good ship had delayed her departure until the morning of the 14th, but what can one expect with a one-eyed black cat aboard!

It was agreed after sailing that the cat should live; perhaps he might counteract the ill-omen of our sailing on the 13th. Now I believe that the cat must have been born on the 13th of the month. Anyhow, we were 21 days going to Gibraltar, where an English gun and two English gunners were put aboard and we left for Oran on the north coast of Africa in the province of Algeria—on the 13th again!

Mildly surprised that we arrived at Oran O.K., I decided to see the town. I saw about twenty dollars worth of the place, and then decided that Africa wasn't so uncivilized. One can't buy gold bricks in Oran, but one can buy 5 franc notes for five dollars, without half trying.

We left Oran without convoy on the evening of the 20th, intending to be in Algiers the next day. I stayed on watch until 5:30 a. m. for two reasons, namely; to pick up submarine warnings and also to figure out a new process by which I could extract money from the skipper to see Algiers when we arrived there.

I came off watch at 5:30 and after hanging all my clothes on a hook in back of the door I turned in.....Well the clothes that were on the hook, and a few others, are on the bottom of the Mediterranean. My B. V. D.s I still have.

The torpedo hit us amidships, right abreast the radio room, just an hour and 20 minutes after I turned in. The explosion must have occurred at least 15 feet under the water as the greater part of damage was done to the hull, and the in-

(c) Press Ill. Svce.

An airplane bombing attack successfully executed is shown in this picture taken above the storehouses and railway sidings at Beyrout harbor. A direct hit by the bomb is revealed by the puff of smoke rising from the pier in the center of the illustration and the commencement of a fire from bombing at a point to the right is disclosed by the larger volume of smoke

terior of the ship was practically intact except for a few of the partitions that were blown down. The table that the wireless instruments were on was blown down and the instruments were scattered all over the floor.

I didn't waste any time in seeing what damage was done but beat it over to where the companionway led to the deck. It had been blown away.

I found a piece of wreckage that I could stand on and then pulled myself up on deck. The ship had started to list immediately after the explosion and as I reached the deck she had begun to straighten up, but was settling fast. Two life-boats had been blown away and the one I was assigned to tipped over as it was being lowered. The usual amount of nervousness prevailed, and I was doing my share and a little more of some one else's.

After everyone was clear of the ship two of the fellows righted the lifeboat and pulled some of us in. A French destroyer was on the horizon and the submarine, after trying to ram the life-boat which later picked us up, passed about three feet from me as I was hanging on to a piece of lumber. The Hun craft started to come up; then apparently seeing the destroyer she quickly submerged and disappeared among the floating wreckage.

The French destroyer, and also an American patrol boat, came circling in and picked up the crew. From the French boat we were landed in a small town called Tenez which we had passed earlier in the morning. We were treated very kindly there, and it was evident that the French people, though they had little themselves, would gladly give what they did have to anyone that needed it more than they.

We were sent by the French Government over the mountains in big auto trucks to a little town called Orleansville, from there taking the train to Algiers where we saw the American consul and were supplied with what clothes could be bought for us. Then is the time to wish for an American tailor!

We were in Algiers three days and left on a French troopship for Marseilles. We arrived in Marseilles at night and left the next night for Bordeaux to take ship for New York.

When we arrived in New York on the 14th of December there was no one any more convinced than I that Sherman was right. It's a great life if you don't weaken.

Special Feature for July

"The Progress of Radio Telephony"

By E. E. BUCHER

In the July issue of THE WIRELESS AGE a special article entitled "The Progress of Radio Telephony," will describe some important developments in radio heretofore unpublished. Combination wireless telegraph and telephone transmitters in which telegraphic and telephonic messages are radiated from the same antenna simultaneously, will be discussed, together with the latest developments in duplex systems. The disclosure of the actual circuits in which vacuum tubes are employed foı the generation of radio frequency currents at high power, and also for their control at speech frequency, make this article a specially valuable contribution to this department of radio research.

A Digest of Electrical Progress

The Growing Need for Hydro-Electric Power—The Testing of Direct Current Meters—Computing the Weights of Conductors—The Uni-Polar Generator—How to Remove Moisture from Transil Oil—An Electrostatic Voltmeter.

The Growing Need for Hydro-Electric Power

ACCORDING to a statement issued by Professor D. M. Folsom, Pacific Coast Petroleum Administrator for Mark L. Requa, a United States Oil Administrator, the electric power requirements of the Pacific Coast increase by 10 to 15 per cent. per annum.

The usual rate of oil consumption in California is almost 110,000,000 barrels per year, which does not meet the present demand. At present 20 per cent. of the total power utilized on the Pacific Coast is developed from hydro-electric plants and 70 per cent. from fuel oil and natural gas. Realizing the seriousness of the matter, the Administration is urging the installation of water-power plants throughout the Coast. In a recent statement, the administrator says: "With the output of oil barely maintained or declining each year this increase must be entirely met through the development of more hydro-electric plants on the Pacific Coast. A conservative estimate of further requirements shows that the installed generating capacity of the plants now on the Pacific Coast should be doubled in five years and tripled in eight years to meet the local requirements for purposes of power, light and heat."

The Testing of Direct Current Meters

IN a recent issue of the Electrical World, J. M. M'Clurg describes a simple arrangement for testing both large and small direct-current meters—that can be adapted to any size load. The board has two distinct loads, one being on 110-volt direct current with resistance for a load up to 32½ amperes. The other load is a storage battery and depends upon the size of the battery used. The magnitude of the load is controlled by a double-pole, double-throw knife switch which makes it possible to leave the triple-pole switch in circuit during the test and changing over from full load to light load by using the double-pole, double-throw switch. This is shown in the diagram, figure 1.

This arrangement saves time, the tester setting the load he desires by the small single-pole, single-throw switches for light load and a carbon rheostat in the battery circuit for full load, thereby leaving but one switch to operate during the test.

A carbon rheostat is provided, the carbons being separated into sections by brass plates. This permits the operator to cut out sections of the plates if the resistance proves too great, the brass plates being connected to the

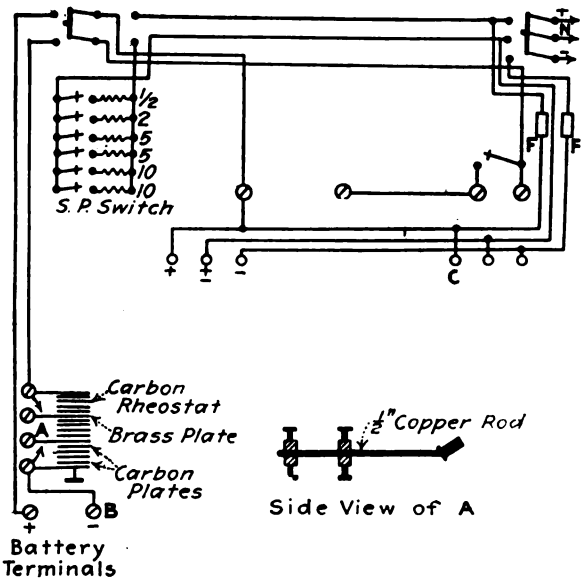


Figure 1—Arrangement for testing direct current meters

binding posts marked A. A copper rod slides through the binding posts so as to short-circuit part or all of the carbon rheostat, as the test requires. This is a convenient carbon rheostat that can be used for light or heavy loads. Of course, by increasing the sizes of the load, terminals, circuits, etc., the board can be built for any desired capacity.

Computing the Weights of Conductors

BY employing the formula W = K × cir. mil × L, the weight of a round conductor of any metal may be readily figured if the size and length of the wire and the weight per circular mil foot of the metal composing it are known. So we are told by Harry H. Barth in a recent issue of the Electrical Review.

In the foregoing formula W = the weight in pounds of the wire;
cir. mil = the area of the conductor in circular mils;
L = the length of the wire in feet;
K = the weight in pounds per circular mil foot of the metal.

Among the commoner metals, the following are the weights in pounds of one circular mil foot of each: Copper, 0.000,003,03; aluminum, 0.000,000,916; galvanized iron, 0.000,002,64; galvanized crucible steel, 0.000,002,64.

The Uni-Polar Generator

SINCE first brought out by Faraday, many direct current generators of the uni-polar type have been constructed, but the manner in which certain types function has been a point much discussed. In the December number of the Physical Review Professor George B. Pegram describes the action of uni-polar induction in terms of the electron theory.

A typical type of uni-polar generator which has occasioned much discussion consists of a cylindrical, permanent, bar magnet rotated by power about its axis and having two stationary brushes applied to its rotating surface. One of these brushes is placed, say, at or near the middle of the magnet. The other is applied near to one end of the magnet. Current flows from these two brushes through an external circuit in the usual manner, the direction being from the middle brush through the magnet and out from the end brush. The particular point of argument is whether the E. M. F. is generated in the substance of the rotating magnet, in spite of the fact that if the magnet carries its magnetic field around with it, this field, apparently, cannot cut the moving substance. Another theory is that the E. M. F. is generated in the stationary part of the circuit external to the brushes.

Professor Pegram takes the stand that the current is generated in the substance of the moving magnet, and he explains his theory in terms of electrons. He concludes, in general, that the E. M. F. generated in an element of a conducting circuit may be produced either by real rate of change in the potential at that point or by the transverse motion of the element with respect to a magnetic field. In event of the latter, the field need not be stationary. The field may or may not be in motion. If the conducting element moves an E. M. F. will be generated therein by the field. As a consequence, a bar magnet generates electromotive force in its own substance when it rotates. Whether the field rotates with the magnet or not is not essential, the only important fact being that the elements of the conductor are moving and are also permeated by a transverse magnetic field.

The author describes experiments repeating the conclusions of Barnett and Kennard regarding uni-polar induction, namely, that the seat of electromotive force is in a moving conductor and is entirely independent of the rotation of the magnetic field. According to the Maxwell field equation in the Lorentz form, no force is exerted on a stationary electron. Therefore there is no E. M. F. induced in stationary conductors in the vicinity of a steadily spinning solenoid carrying a constant current. But when the electron moves there is an E. M. F. on electrons in moving conductors which may be easily seen to be quantitatively just what would be computed on the basis of the calculation of the "rate of cutting of magnetic lines," assuming that the lines of the magnetic field would remain stationary with the conductors rotating.

How to Remove Moisture from Transil Oil

THE best known method of removing moisture from oil is that of using a filter such as the larger electrical manufacturers market specially for the purpose. But these are not always available, and some other method must be improvised.

In a current issue of the Electrical Review Mr. M. S. Montgomery describes a temporary scheme whereby all moisture is removed through a bed of calcium chloride. The particular transformer in which the oil was filtered was of 2,000 kw. capacity and constructed for high voltage, hence it was imperative that the oil should be free of all moisture. The writer goes on to remark that while many ideas suggested themselves, such as heating the oil at atmospheric pressure, or better still in a vacuum, it was decided that it would be safer and quicker to absorb the moisture instead of attempting to drive it off as this latter method is often difficult to perform whilst there is always the possibility of overheating the oil and thereby damaging it.

Just how the process is carried on is shown in the diagram of figure 2.

The oil was passed through a bed of calcium chloride which picked up the

moisture and had no deleterious effects upon the oil. The oil was passed through two separated beds of calcium chloride and then through two filters, each of which was made up of two double thicknesses of cheese cloth that had been previously dried by heating. Each chloride bed was made up by

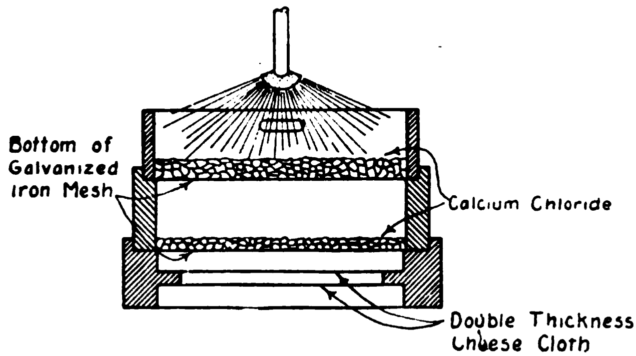


Figure 2—Arrangement of calcium chloride trays and cheese cloth filter for removal of moisture from oil with minimum spillage

fastening a fine mesh to a wooden frame, the one fitting into the other as shown. Beneath, to prevent pieces of chloride being carried over with the treated oil, four pieces of cheese cloth were fastened in a separate frame. This system permitted the oil to be treated as fast as it could be poured out of the oil drum.

To determine definitely that the moisture had been removed, calcium carbide was used to detect its presence after each drum had received the oil. Moisture or water tends to sink to the bottom of any container holding oil, although after agitation a considerable amount of moisture may be held in suspension. Numerous samples were taken in a glass beaker. Into this was dropped a few small lumps of carbide. With the untreated oil a column of bubbles invariably arose from the lumps, indicating chemical action due to the effect of the water on the carbide. With properly treated oil all evidences of bubbles were absent.

An Electrostatic Voltmeter

AN interesting portable instrument for measuring very high voltages such as are used in electrostatic fume and dust precipitation has been described in the Electrical World. The instrument is a modified form of the Kelvin guard-ring galvanometer described in the Electrical World of May 13, 1916. A sketch of the meter is shown in figure 3. The disk D forms one element of a balance beam. The insulating support for the upper plate is removable at the base, and the whole packs readily in a flat box and is easily put together for use.

The instrument is put into operation as follows: Screw S is adjusted so that the upper surface of the disk D is flush with the upper surface of the guard ring G—that is, so that the pointer of the balance registers zero while a 500-milligram weight rests at W. This weight is then removed, whereupon the disk D falls slightly,—that is, until the beam makes contact at T. The plate P is then connected to the high voltage line, while it is some distance from the guard-ring G; it is then lowered by means of a knurled head and ratchet, which unwinds a silk string until the disk D is attracted so as to again be just flush with the guard-ring G—that is, so that the pointer on the beam indicates zero. The distance between the plates is then read from the scale by the indicator I, which may be marked to read in volts directly.

Mr. E. R. Wolcott gives the following equation for design and calibration:

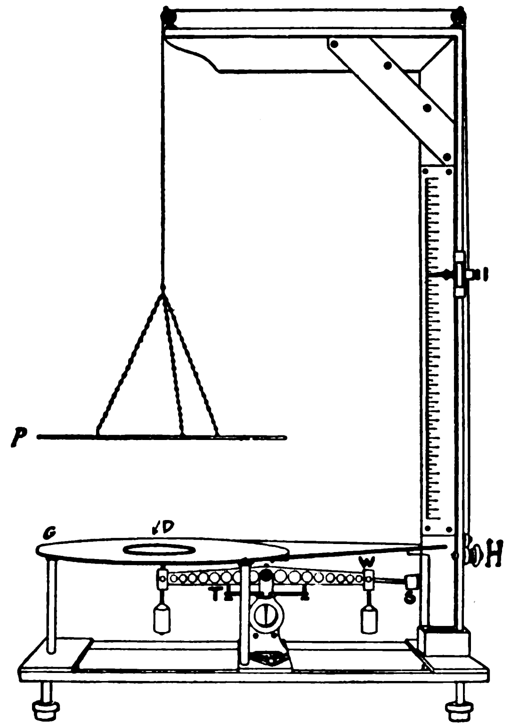


Figure 3—Sketch of electrostatic volt-meter

Since the electrostatic attraction is measured by comparison with the attraction of gravity, if the mass of the weight at W and the area of the disk D are known, the relation between the voltage e and the distance d between the plate P and guard ring G can be expressed as follows:

$$e = 300\ d\sqrt{\frac{8\pi m g}{\pi r^2}},\ \text{where}$$

e = volts in electromagnetic units;
d = the distance between the plate P and guard-ring G in cm.;
m = the mass of weight added at W in grams;
g = the acceleration of gravity = 980.6;
r = the radius of the disk D in cm.;
300 = the constant of transformation from electrostatic to electromagnetic units.

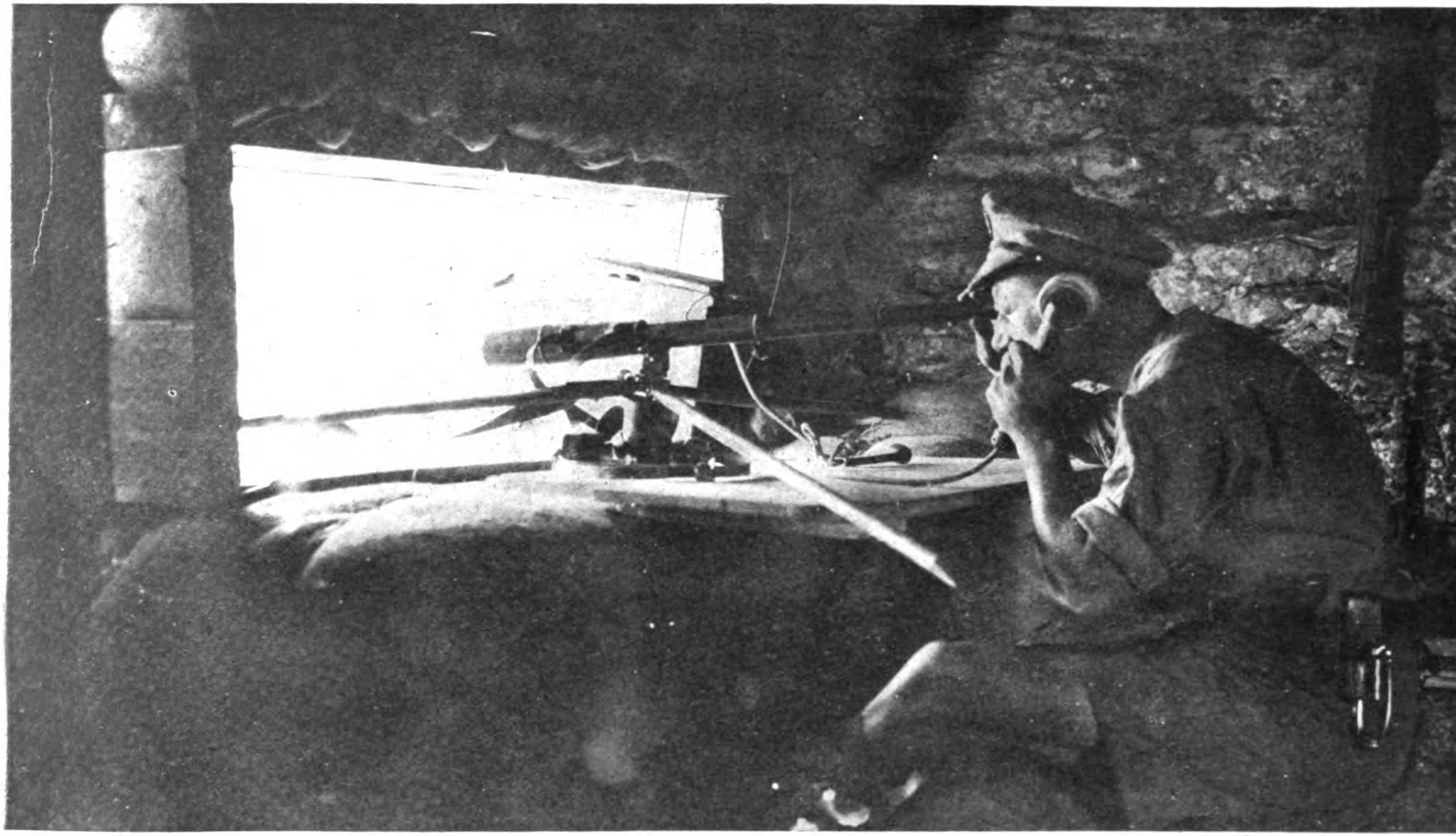
If $m = 500$ milligrams, and $r = 1.5$ in. $= 3.8$ cm., then when $d = 1$ cm.,

$$e = 300\sqrt{\frac{8 \times 0.5 \times 980.6}{14.5}} = 4935 \text{ volts per cm.}$$

The diameter of the plate P and the guard-ring G should be larger than the maximum distance to which they are separated.

The diameter of plate P in figure 3 was 10 inches. The instrument was used to measure 100,000 volts. Accordingly, the spacing between the plate P and the guard-ring G was about 20 centimeters.

The accuracy of the instrument depends upon that of the beam, which, the writer remarks, is readily constructed so as to permit of readings within 1 per cent.



(c) Int. Film Svce.

So accustomed have Americans become to the detailed reports of fire spotting from airplanes and artillery control by wireless, the direction of bombardments from the ground is almost lost sight of. In this picture a British signalman is shown in summer garb directing his battery from a dugout

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Tikker for the Reception of Undamped Oscillations

This is the plan and description of a mechanical tikker which I recently constructed. I took as a working basis, an armature of a small 60-cycle Westinghouse series motor. The experimenter who can obtain a similar motor and desires to follow out my construction should proceed as follows:

First, remove the armature windings and magnetic core from the shaft, taking care not to disturb the clamping rings which hold the commutator together.

Next, remove the bearings from the motor, remount them, and re-align the shaft in the bearings. Take a very fine, light piece of watch spring, bend one end into a V shape so that it will rest on the commutator as a brush, and fasten the other end under a binding post. The tip of the brush should be sharp so that it will not bridge two sections of the commutator. With a small soldering iron, solder together the sections of the rim D (figure 1) and then solder a wire in one of the joints. The other end of the wire is soldered to the long clamping ring H, which, in turn, serves as a drive wheel. A wire extends from one of the bearing supports (which, by the way, should be of metal) to another binding post. The instrument can now be considered complete.

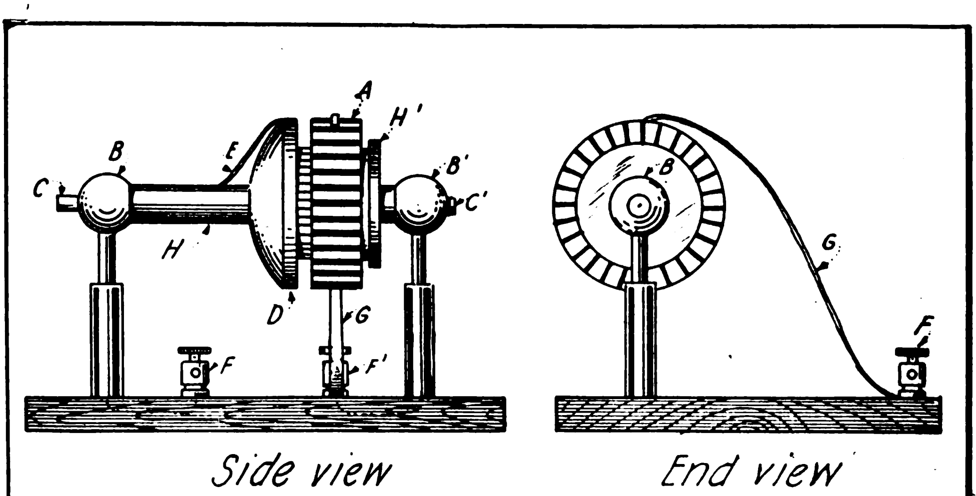


Figure 1 *First prize article* *Figure 2*

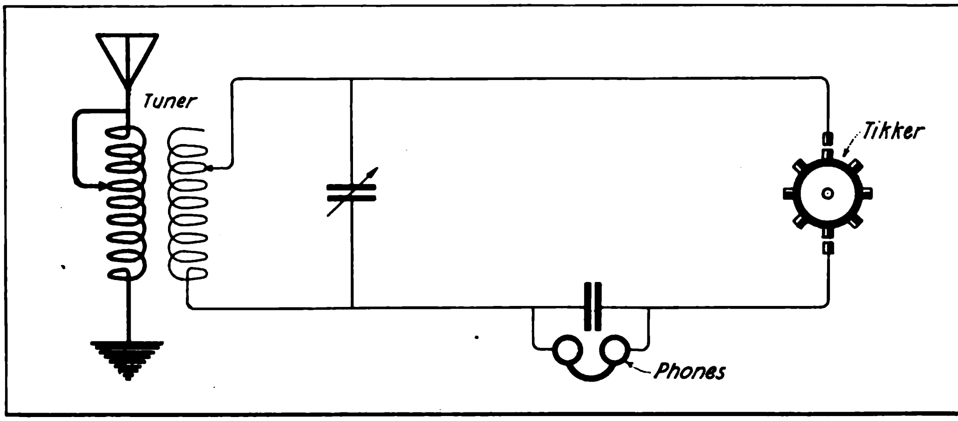


Figure 3—First prize article

The tikker should be driven by motor with a speed control. There may be from 1,000 to 1,500 breaks per second. The most effective way of connecting the tikker is shown in figure 3. If the circuit is tuned to a wave of say 6,000 meters and the signals are not heard, the experimenter should increase or decrease the speed of the tikker whereupon the signals will be received providing the transmitting station is sending. If the tikker revolves too rapidly, the pitch of the note will be above audibility, but the proper speed regulation can soon be found. I used this device before the war and it proved very efficient. The complete details of construction are given in figures 1 and 2, figure 1 showing the mounting of the commutator, and figure 2, the position of the brush.

B. L. SMITH, *Concord, Mass.*

SECOND PRIZE, FIVE DOLLARS

Receiving Set Applicable to the Reception of Damped or Undamped Waves

I have noticed many odd looking receiving sets in past issues of THE WIRELESS AGE, and I take the liberty of submitting sketches of a long wave tuner which I constructed some time ago for the reception of damped or un-

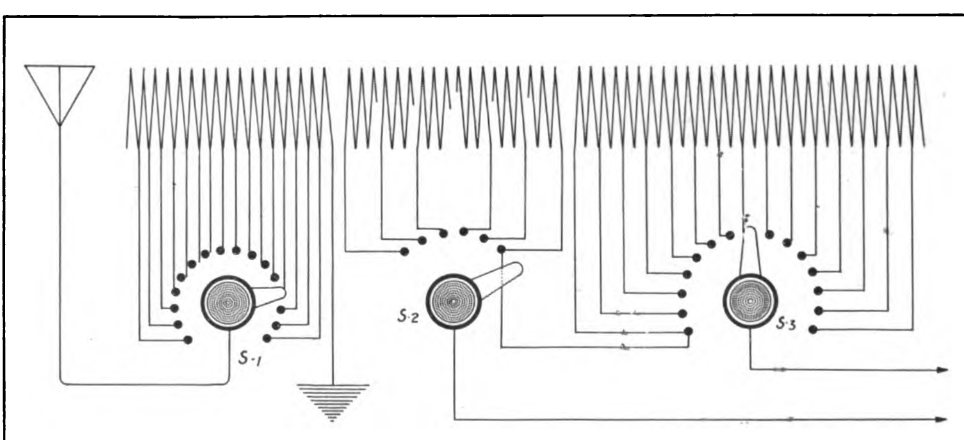


Figure 1—Second prize article

damped waves, with the hope that it will prove of interest.

Figure 2 shows the external appearance of the cabinet; figure 1, the tuner, and figure 3, the circuit. In figure 2, "A" is the aerial post, and "G" the ground. S-1 is a switch for tuning the primary, while S-2 and S-3 are for tuning the secondary. C-1 is a variable condenser across the 'phones. The other connections are plainly shown. No dimensions are given as to constructional details, except for the coupler, which is somewhat out of the ordinary. Details of construction accompany the drawing and no remarks are necessary, except that attention might be drawn to S-2 (the coupling switch). As is seen, the coupling is mechanically fixed, but the switch S-2 makes possible a coupling, mechanically speaking, of from ⅛-inch to 6 inches or more, which is said to be highly desirable for close tuning on the long wave arc signals.

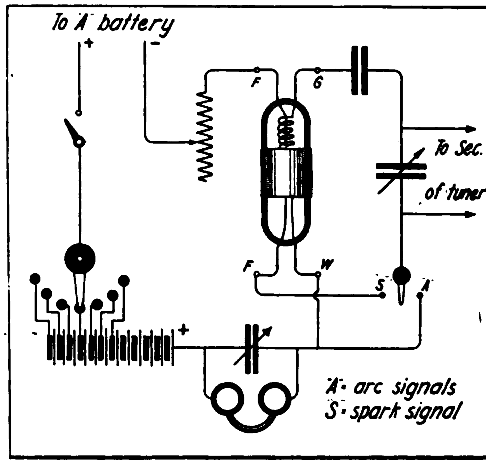


Figure 3—Second prize article

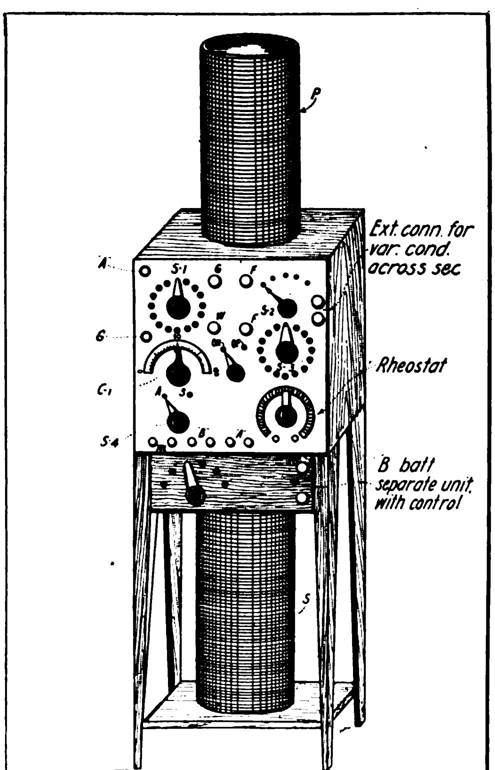


Figure 2—Second prize article

As will be noted in figure 2, there are two binding posts for the external connection of a variable condenser across the secondary. This scheme was resorted to so as to permit the use of this variable in other circuits.

I have not shown a variometer which is supposed to be used in the aerial circuit for close tuning—in other words, to permit regulation of the inductance between the primary taps. The variometer has a rotor 7 inches in diameter and is constructed in the usual manner.

W. T. Gravely, *Danville, Va.*

THIRD PRIZE, THREE DOLLARS

An Oscillation Circuit for the Reception of Damped and Undamped Waves

I wish to submit to the "Experimental Section" of your magazine the following description of a receiving apparatus for the reception of damped and undamped waves, which I have devised in anticipation of the grand post bellum opening. The cabinet may be of interest to those amateurs who have a few moments' spare time to experiment in preparation for this great event.

Figure 1 shows the general external appearance of the apparatus. The construction follows:

The panel should be made of bass wood, light and substantial. It should be 18 inches long, 14 inches wide and

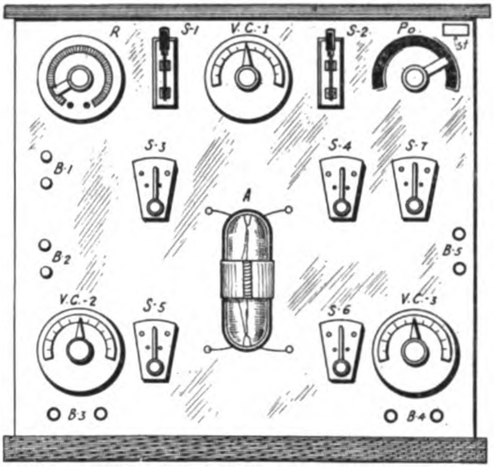


Figure 1—Third prize article

3½ inches deep. It can be richly grained and polished. The thickness of the board should be about 7/16 inches. Three holes 3½ inches in diameter should be cut in the panel cover to admit the variable condensers. All wiring, of course, must be done on the back of the panel cover.

As shown in figures 1 and 2 the instruments of the complete receiver, with the exception of loose coupler, 'phones, and coil (mounted on the outside of the cabinet) are contained inside the cabinet.

The lettering on the diagrams is explained as follows:

R is a rheostat for regulating the filament battery A, which should be 6 volts, 40 ampere hours capacity.

S-1, S-2 is a Trumbell porcelain base, single pole, double throw switch, which is rarely used except to throw the system out of commission in event that meddlers prove too attentive.

Po. is a potentiometer to regulate the E. M. F. of battery B—the high voltage battery of from 45 to 55 volts.

S-3, S-4, S-5, S-6, are two-point switches mounted on hard rubber bases. These permit the apparatus to be used for either spark or arc reception. For spark signals they are moved to the right and for arc signals to the left.

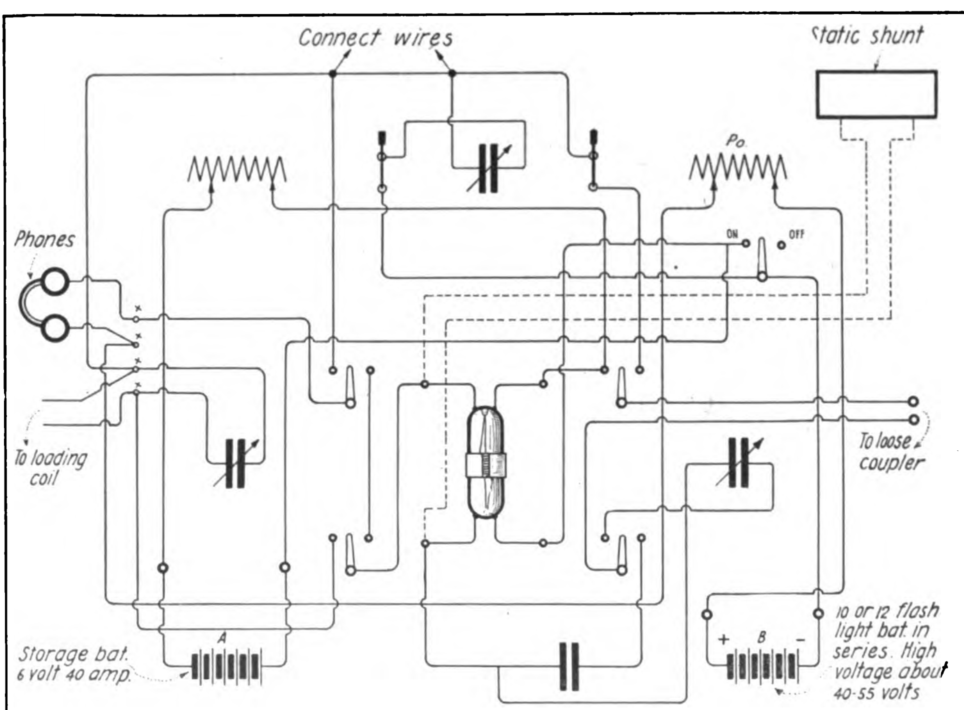


Figure 2—Third prize article

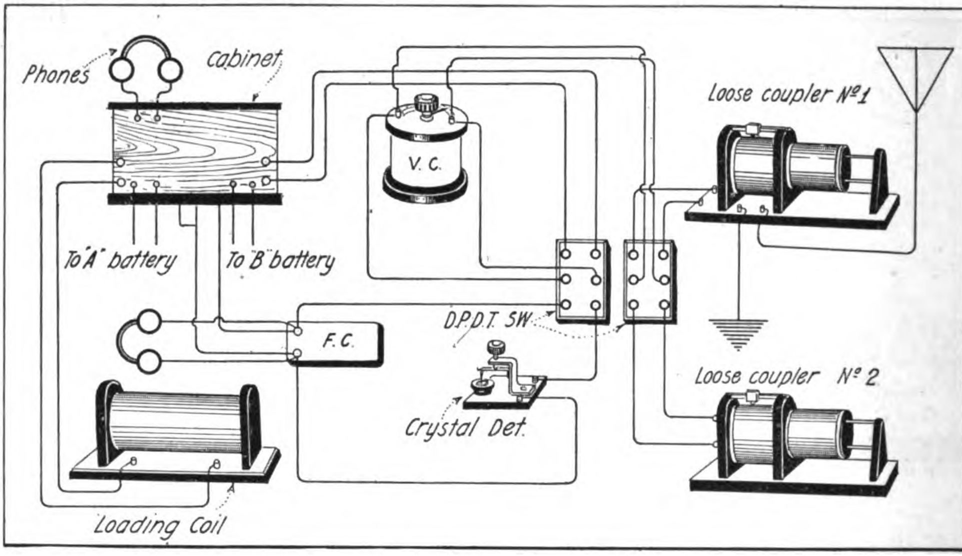


Figure 3—Third prize article

VC-1, 2, 3, are variable condensers of .001 microfarad capacity each. Their use can be easily understood by a careful study of figure 2.

B-1, B-2, B-3, B-4, B-5, respectively, are binding posts for 'phones, loading coil, battery A, and loose coupler.

A is an audiotron for the reception of damped and undamped waves. St. is a static shunt to prevent the accumulation of high potential on the grid or plate condensers. The static shunt is indicated by diagonal lines. Its resistance can thus be either increased or decreased.

Switch S-7 throws the entire system into action, i.e., it lights the audiotron from battery A. When S-7 is thrown to the right the set is out of commission. FC is a fixed condenser.

This set, before the War, gave perfect satisfaction. With it I have received messages over distances up to 3,000 miles.

Experimenters who have the opportunity to construct the equipment described, I feel sure will be pleased with the results they obtain.

I also submit a complete diagram, figure 3, for switching from the valve to a crystal detector condenser. FC is filled with pure castor oil thereby increasing the capacity five times.

ALBERT J. C. VIAN, *Minot, N. D.*

July Prize Articles

"Howler" Code Practice Apparatus

Describing a novel apparatus for the production of audio frequency currents.

Super-Sensitive Receiving Set

Detailed instructions are given for its construction and operation.

A Telephone Cabinet

An interesting cabinet which any amateur can make.

(c) Press Ill. Svce.

The lone sentinel amid the snow-capped mountains on the Italian front is here shown maintaining the vital telephonic communication upon which all major operations are based

The Monthly Service Bulletin of the

NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headqrarters, 25 Elm St., New York

Dreamin' O' Seventeen

By Fred W. Jameson

WHERE is the radio enthusiast whose heart doesn't pine for the glorious winter nights prior to April 10th, 1917? The amateur stations have been closed just long enough to make one homesick for the glowing audion, the glistening switch points, and the sweet odor of orange shellac which gave a professional finish to our home-made apparatus. The Wireless Age has sensed this spirit of longing that fills the hearts of all true radio experimenters and invites accounts of experiences prior to the closing of all stations. Nothing else that could be published will do more to keep alive the love of the regal sport that was once within the grasp of any who wished it.

Every radio enthusiast hearkens back to some particular night when the voices in the ether seemed unusually distinct and their messages exceptionally entertaining. I recall one of those nights, and while my log records no unusual long distance captures, it recites events that always will bring a pleasing thrill. It was not a "freak" night, but just one of those snappy winter nights when old man QRN was off the job and QRM was unusually decent.

* * *

NAA had tapped off ten o'clock and the signals were very distinct and loud. A slight change of coupling and switches, and here was Key West ripping out an alarming lot of news about loose bell buoys and dangerous derelicts. A drop back to 200 meters and hundreds of amateurs in all parts of the country could be heard. At 300 a medley of piping notes from ships down in the gulf chimed musically. Some night for radio! I change the simple hookup to a regenerative one, using two variometers as described in "How to Conduct a Radio Club" and the effect was marvelous. A Standard Oil tanker, reporting her position three hundred miles from Tampico, roars in so shrill and loud that I lay off the phones and easily read the signals while sitting in an adjacent room. St. Augustine, Florida, (NAP) hailing a ship, and San Juan, Porto Rico (NAU) come in loud and clear.

Then comes a deafening bombardment from a Ford spark coil in the north part of town. Nothing to do but shut off the audion and wait until the "ham" gets tired. A high wind is blowing and snow sifts against the window panes in fitful furious gusts. The aerial high overhead can be heard whistling shrilly as the wind tears through it; the taut aerial ropes slap noisily against the steel masts.

The air is full of news when once again the audion is switched on. A station out at Victor, Colorado, is complaining of the severe wind in the mountains; —"am afraid my aerial will go any min." he wails. A slight change of switches and coupling and here is Colon, Panama,

finishing the night's business with a brief chat about the excessive heat!

What king in his gilded palace can boast a sport more regal than that which I enjoy in my humble den, with the thermometer at two below outside and the wind howling frantically at my aerial high over the fertile hills of eastern Kansas! The centre of the United States and the hub of three thousand miles of gossip by land and sea! What Pandora's box can compare with this magic box of mine that lets me hear the traveler at sea—still two days from port—ordering a room with bath reserved for him in the best hotel in Galveston?

Where is the magic lamp, rub it as you may, that will bring to your ears the booming note of the sinister drab British battleship lying seventeen miles off Sandy Hook, solemnly warning mariners to beware of enemy submarines and "display no unnecessary lights"! The magic carpet could never carry me to more inspiring scenes than those this simple contraption of wood and wire brings close to hand. Here is the weird note of VPP at Nassau, Bahama Islands, advising a Canadian station regarding a shipment of tortoise shell. NAA opens up again with a press report full of war news; Key West is shrilly feeding seagoing folks with the latest news from the blood-stained fields of France and Belgium. War, war, nothing but war! BZQ booms again with a glorious recital of British and French war gains. Down in turbulent Mexico one of the (X) stations,—what an awful call to decipher—opens up in a shrill 500-cycle falsetto and talks Spanish to the Mexican who sits sweltering in his room at Campeachy. Presently his answering note is heard. WHK at New Orleans, always a busy station, is unusually busy tonight and ships on the gulf are whining through the ether in a mad medley of skeeter voices. What a lot of interesting gossip they convey to a landsman in a snowbound town thousands of miles from salt water!

But ships are so common to the operator who has a good outfit! I try for bigger game. Ah, here is WHB (New York Herald) sending press,—interesting, too. And WRU (Port Arthur,

Texas), another busy gulf station, is impatiently ordering an interfering Norwegian to stand by and keep out until his turn comes. Then WSE (Seagate, N. Y.) comes in clear and distinct; and Miami, Florida, (WST) is heard, equally loud. WZO a new station at Fort Bliss, is trying out with WUJ at Fort Sam Houston, Texas. WUJ comes back with a roar that is painfully loud.

Then down to 200 meters and just listen to the amateurs! From Denver to New York; from Bismarck, N. D. ("—thirty below hr tonite") to the Fifth District stations down in Texas, Arkansas and Louisiana, all are going strong for it seems to be a good night for radio all over the country. Some are interfering with idle gossip, others are trying to prove to NAJ at Great Lakes, that the amateurs will be a valuable asset in case of war!

During the afternoon I had copied POZ and OUI, the big German stations, sending bank transfers supposedly—war dope most likely—now let's hear what Tuckerton and Sayville have to say in reply. The loading inductances are hooked in and the beautiful fife notes of WGG ring musically through the room. The note varies as the capacity of my body interferes. Colon, Panama, is on and working fast. WSL (Sayville) can be heard fifty feet from the phones. NAO (Charleston, S. C.) is busy with a beautiful note; Darien, Panama (NBA) has a message for the maneuver fleet off Cuba; Arlington, (NAA) is working in code; New Orleans (NAT) is using its arc set on a distant station, and what is this faint voice from afar? NPG (Yerba Buena, Cal.) calling Washington! And here is NPL (San Diego, Cal.) also wanting NAA.....

Is it any wonder the radio enthusiast used to stay awake half the night when old QRN was off the job?

Wilbur Wilkerson, of Kansas City, Kansas, well known to radio amateurs in the middle west by the government call letters 9FF, was killed in battle in France, March 20th. Wilkerson, who was an enthusiastic radio amateur enlisted in the 117th Field Signal Battalion, Co. A., last fall. Secretary Baker, who was at the front at the time Wil-

kerson was killed, personally attended the funeral. A French officer laid the *croix de guerre* on the coffin as it was lowered into the grave.

A number of inquiries have been received from former experimenters asking why we have not published diagrams of earth-conduction telegraph systems, so that experimenters could communicate without wires, but not by Hertzian waves. The reasons are: First, we do not know what attitude the Government officials would take towards such methods of communication, and second, we do not wish to encourage anything among experimenters which would tend to attract suspicion to their operations. Earth conduction systems are limited in their range, but it may be possible by the use of sensitive vacuum valve amplifiers to increase the distance greatly. Nevertheless, we would advise experimenters not to engage in any form of wireless communication during the war. Time will be better spent in educating themselves in the fundamentals of the art, thus preparing themselves to build better equipment when they are again allowed to open their stations.

It is again necessary to state that we have no definite information concerning the vacuum valve situation. Just where amateurs will be able to purchase evacuated tubes after the war we cannot say; but it is highly probable that such tubes will be available for amateurs' use. It is equally possible that the vacuum tube will came in for considerable use on the part of amateurs as for purposes of transmission. At least the tube will permit communication over short ranges and it will provide a transmitter of greater simplicity than the amateur ordinarily is accustomed to use.

A number of amateurs who are studying the vacuum valve circuits apparently are disturbed at the complicated circuits which they encounter in regenerative systems. It may be said that the majority of systems described by experimenters from time to time work along the same general lines, the difference lying merely in the arrangement of the apparatus or in its

connection. There are two ways of obtaining regenerative coupling—by electromagnetic or by electrostatic induction. So long as the plate and grid circuits of the tube are coupled one way or the other, regeneration results.

Have you heard the story about O. A. B? He was an Indiana ham amateur whom the gods of war had placed on a trans-Atlantic cargo vessel. As he neared the submarine zone he became more and more concerned over the possibilities of an attack. Prepared for most anything, he cautiously tuned the apparatus to take in any signals that might be coming in his direction, such as warnings from land stations or vessels within range. His anxiety was increased by constant prodding from his companions. He obtained response, but in an unexpected way. A three-inch shell passed right through the cabin forward of that given over to the radio set, smashing his ports and breaking off the lead-in wires for the aerial.

Leaping from his cabin, he rushed back and forth on the deck and yelled:

"We've been shelled! We've been shelled!"

"Get back in your blooming bunk," the Captain yelled, "and call for help!"

Shivering in the knees, he stammered: "Captain, whom should I call?"

"Call? You confounded lunkhead! Call Paris, New York, Berlin, the Kaiser! Call anybody, anything! Tell them that we are shelled."

Apparently, he followed out instructions to the detail, for, according to the second operator, this is the message he sent out: "To all ships: We've been shelled by something—we don't know what."

There was no doubt later concerning the origin of the shelling, for within fifteen minutes they had a three-hour engagement with a submarine. There were no casualties.

The remarks of A. R. Q., in the British Channel, were almost equally ludicrous. He was requested by a British Patrol vessel to "reduce his wave length and power."

He replied, "Sorry, O. M., our cap-

tain won't allow us to take down the aerial."

"Have you heard a wireless signal of late, and what did it sound like?" an inquirer asked in the Association office the other day.

"Yes," was the reply, "we have heard many signals, but they were artificially made."

"I should like very much to hear the old dot and dash buzz of a wireless telegraph set," followed this observation.

"Easy," we told him. "There's a space in the first line of trenches in France waiting for you. Not only can you hear the sputter of wireless sparks there, but plenty of staccato, mezzo, and basso accompaniments."

The inquirer enlisted the same afternoon.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

D. R. Q., St. Louis, Mo.:

Radio frequency sparks are those occurring at rates above 20,000 per second. This is, of course, above audibility, and no sound will be obtained in the receiving telephone at the receiving station. The radiations from such systems assume the nature of undamped waves, but are not strictly so. In transmitters giving radio frequent spark discharges, it is necessary to interrupt these discharges at the receiving station at an audio frequency approximately 500 or 600 times per second, or possibly more, in order that the maximum response from the telephone can be obtained. Such systems are not widely used. A multiplate or quenched spark discharger is now preferred, in damped wave telegraphy.

Replying to your last query, no wireless apparatus for the present can be purchased by an experimenter or sold by a supply house without permission from the Government authorities. It is considered a violation of the President's order for an amateur to construct radio apparatus during this period. Whether or not the Government will allow you to construct the apparatus you mention in your communication

can be ascertained by addressing the District Communication Superintendent of the U. S. Naval Radio Service at Chicago, Ill.

The sounds you hear from the rod of soft iron when it is magnetized by a strong electric current arise from the sudden motion of the molecules of the iron due to magnetization and demagnetization.

* * *

O. E. C., Boston, Mass., inquires:

Ques.—(1) I would like the details of construction of an audio frequency transformer for amplifying the signals from a silicon detector by means of a three-electrode vacuum valve. I have tried the various designs shown from time to time in publications, but have been unable to obtain results. Please state the dimensions of a reliable, working transformer.

Ans.—(1) You can obtain considerable amplification of the incoming signals by merely connecting the grid and filament of a vacuum valve across the usual fixed condenser in the crystal rectifier circuit. This condenser should be of small capacity and care should be taken that the grid element of the vacuum valve is connected on the high potential side of the secondary coil. Either an inductively or conductively coupled transformer may be employed. They should be connected in shunt to the condenser. One type of coil which has given good results has primary inductance of 20 henries and secondary inductance of 90 to 100 henries (fitted with an iron core). The primary and secondary coils are generally wound with No. 32 and No. 34 B. & S. wire, respectively. With certain types of vacuum valves, it is desirable in a circuit of this kind to insert a grid battery in series with the grid, that is to say, a four-volt battery unit is shunted by a potentiometer and connected between the negative side of the filament and the terminal of the secondary winding of the iron core transformer opposite to that connected to the grid.

That you were unable to obtain the desired results with the transformer you describe in your communication is likely due to an imperfect vacuum tube. It may have nothing to do with the design of the transformer. Perhaps the construction of this tube was such that it did not give the desired operating characteristic for audio frequency amplification. But this can be compensated for to a certain extent by using the grid battery mentioned.

* * *

S. W. H., Glencoe, Ill., inquires:

Ques.—(1) Is there any difference between a secondary shunt condenser of .001 microfarad capacity, a plate circuit condenser of .001 microfarad capacity, and a telephone condenser of the same value?

Ans.—(1) There is no difference, but the telephone condenser is usually of fixed capacity.

Ques.—(2) Is a variable static shunt and a potentiometer for the high voltage battery necessary for an undamped receiving set?

Ans.—(2) The potentiometer is not absolutely necessary, but it gives a closeness of control of the plate circuit voltage that cannot be obtained otherwise. A shunt across the grid condenser of a vacuum tube which is highly exhausted is essential, for otherwise, the charge accumulating on the grid will reach such a high negative value as to open up the plate circuit and render the tube inoperative.

Ques.—(3) Please explain how to make a variable static shunt.

Ans.—(3) It may be constructed by mounting two binding posts with a strip of paper between them. Several lead pencil lines may be drawn from one post to the other until the desired resistance is obtained.

Ques.—(4) Can you tell me where I can purchase tubes 40 inches in length and six inches in diameter for use as tuning coils?

Ans.—(4) These can be purchased from Ware & Co., Watt street, New York.

Ques.—(5) Referring to the diagram on page 335 of the January, 1918, issue of THE WIRELESS AGE, I do not understand the function of the coils L-8, L-9, and the changeover switch S-1.

Ans.—(5) Coils L-8, L-9, constitute a regenerative coupler; that is, the plate and grid circuits are magnetically coupled at that point. Please take note in this diagram, that the coils L-6, L-8, should be connected and that the potentiometer, Po, should be shunted around the plate battery B. The changeover switch S-1 changes the connections of the apparatus so that either short wave transformer L-1, L-2, or long wave transformer L-5, L-6 can be connected to the vacuum tube. During the war period you are not permitted to construct wireless apparatus of any kind.

* * *

R. W., Plainfield, N. J., inquires:

Ques.—(1) What should be the primary voltage of a coil to deliver a 6-inch spark?

Ans.—(1) 12 to 24 volts D.C. should be employed.

Ques.—(2) What is the watt rating of the coil?

Ans.—(2) It would consume approximately 125 watts.

Ques.—(3) What size should the core be?

Ans.—(3) It should be 1½ inches in diameter and 14 inches in length, composed of a bundle of No. 28 soft iron wires.

Ques.—(4) What should be the dimensions of the secondary pies or windings?

Ans.—(4) The secondary should be divided up into 20 sections. The entire winding will require approximately 12 lbs., which should be equally divided between the sections. When completed it will be about 10 inches in length. Use No. 32 B. & S. wire.

Ques.—(5) Would No. 14 S. C. C. wire be correct for the primary winding?

Ans.—(5) Use No. 12 B. & S. S.S.C. for wire wound in two layers.

Comments on Receiving Phenomena

READERS of the February issue of THE WIRELESS AGE noticed on page 440, comments of the radio operator of the U. S. S. Roosevelt on certain phenomena of receiving which he observed in the North Pacific and Bering Sea, namely, that a decided change of weather, such as from stormy to calm and vice versa, invariably is accompanied by good receiving weather, i. e., no static or atmospherics. This operator's remarks have been both substantiated and disproven by observers at several points.

B. M. Joachim of St. Raymond, Quebec, Canada, comments as follows:

"P. B. D., Radio Operator, U. S. S. Roosevelt, in the last issue of THE WIRELESS AGE inquired whether any wireless operator had noticed the phenomenon that receiving is better when a sudden change in weather is to be expected. I must say that I have very often noticed the fact. Assuming 50 per cent. to be a fairly good average reception of Washington Time Signals, this percentage was doubled when changes in the weather conditions were to take place.

"My opinion is that the aerial is a pretty good barometer for the attentive operator.

"In case of Aurora Borealis (they are very important here), good reception is quite impossible, for reasons which I cannot explain.

"My station is located 71° 50′ west of Greenwich by 47° 55′ north; in a cold, mountainous country. This winter's lowest temperature was 62° F. below zero on December 30, 1917."

V. C. McIllvaine, radio operator on the S. S. Freeport Sulphur No. 2, apparently has obtained exact opposite results. He says:

"Referring to comment of P. B. D., radio operator, U. S. S. Roosevelt, page 440 of February issue of THE WIRELESS AGE, I wish to state that my observations seem to be exactly opposite to his. While not working in the North Pacific or Bering Sea, but rather in the Gulf of Mexico, during the winter months especially, a blow from the North is invariably preceded by static. The static would precede

the 'norther' by from 6 to 18 or 20 hours, and the strength of the blow may be roughly estimated by the intensity of the static. During the blow, however, the atmosphere is very clear, being very excellent weather for radio work."

An amateur of Ohio has observed results similar to P. B. D. He writes as follows:

"I notice that P. B. D., radio operator, U. S. S. Roosevelt, states that he has noticed that a decided change in the weather during the winter is invariably accompanied by good receiving weather. I operated a wireless station in western Ohio for several years and have often remarked the same thing, which, for us, was especially noticeable at a time when the weather was just commencing to moderate considerably after a cold wave. At such times not only was there a remarkable freedom from static, but the signals came in with unusual loudness and there was less than the usual amount of 'fading' with distant stations. The best receiving results that we ever obtained were at these intervals.

"I should like to hear the experience of others."

A Radio Phenomenon

SMOKE passing through an aerial has the power to transmit heavy deposits of static. Perhaps ship operators have been aware of this fact for a long time, but it is probably news to many land amateurs. The phenomenon was first called to my attention at Fort Leavenworth where the college station "WUV" experienced considerable trouble from a mysterious source. Major J. O. Mauborgne, who took charge of the Signal School there last fall, quickly traced the trouble to its source and proved conclusively that the frequent violent surges of static which would appear and suddenly disappear on nights which were unusually free from atmospheric disturbances, were caused by smoke clouds from passing trains. He expressed a determination at the time to write a paper on his investigations of the phenomenon, but was called for service in the radio laboratories in Washington and has no

doubt been too busy to give the matter further thought.

The writer, whose aerial was also exposed to smoke clouds from passing trains, made frequent tests up until the time the stations were ordered closed, and a passing train never failed to disturb the station when the wind was favorable for passing the smoke through the aerial. The charge of static would "spill" the audion and made a fine display in the variable condenser which was used in series with the antenna to shorten the wave-length. F. W. J.

Improved Apparatus

Bunnell Straight Line Radio Key (Ghegan Patent)

The object of this design (figure 1) is to provide a radio key having removable or renewable contacts that can be kept in perfect alignment until completely worn out. This not only economizes in respect to renewals but by giving better surface contacts between the points, eliminates the fading or changing of strength of signals caused by imperfect or unevenly worn points. This is accomplished by mounting the lower contact point on a ball-bearing stud having a clamping device for holding it permanently when in proper adjustment with the upper contact.

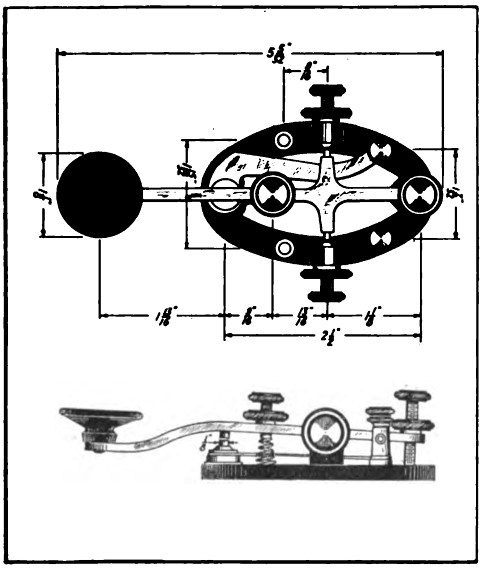


Figure 1—Bunnell straight line radio key

The upper contact is not mounted directly on the lever, but is attached to the end of a set screw passing through the lever directly over the lower contact.

By this arrangement increased lever-play, caused by wearing of contacts is not taken up at the back adjustment screw as in the ordinary key, but by lowering the upper contact which permits uniform surface contact until the points are worn off. This is not possible with the usual type of key.

This arrangement has the further advantage of keeping the lever knob always at the same height from the operating table. Operators will find this a very desirable key.

A New Small Squirrel-Cage Induction Motor

A new line of induction motors has been recently placed on the market by the Crocker-Wheeler Company, Ampere, N. J. These motors, known as the C.W. Form P Motors, are of the squirrel-cage type, ranging in size from one-half to three horsepower, and are designed for constant-speed operation on sixty-cycle polyphase circuits.

The mechanical construction is compact, rugged, and simple. Rigid frames and end shields, liberally designed shafts and bearings, ample air gaps and good insulation enable these motors to withstand the severe service to which these machines are generally put. They possess good starting torque and high power-factor.

Among the special features of these motors is their efficient ventilation. A number of the rotor bars project for a short distance at each end of the rotor core. These projecting ends serve as efficient fans. Attached to the inside of each of the bearing shields is a pressed steel guide that separates the incoming from the outgoing air. Air is thus drawn into the motor at each end through openings near the shaft

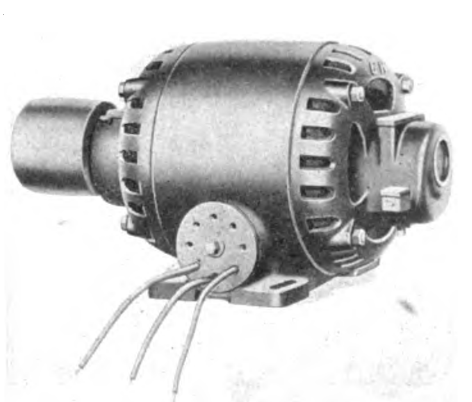


Figure 1—The squirrel cage motor assembled

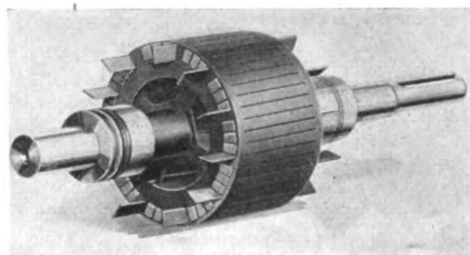


Figure 2—Stator having well insulated windings

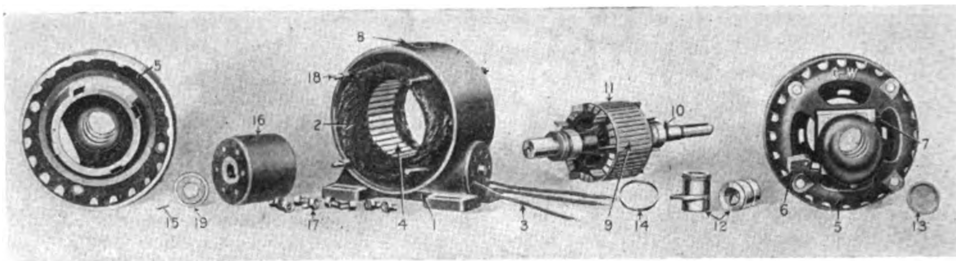


Figure 3—The motor disassembled

and then forced by the fans against the stator windings, around the ends, and finally out through the holes near the outer periphery of the shields. This construction prevents the outgoing warm air from mixing with the air being drawn into the motor. A maximum cooling effect with a minimum of windage loss is thus obtained.

Strong insulation of the stator windings is obtained by placing the coils in well insulated slots and impregnating the complete core and winding with a special varnish which renders them moisture-proof and enables them to withstand acid fumes. After the core and coils are removed from the impregnating tanks they are baked, and again dipped in varnish and baked.

The bearings are large, with oil grooves so located that no matter in what direction the belt-pull may be there will be a film of oil between the shaft and the bearing, thus reducing friction to a minimum. Dust and dirt are kept out of the bearings by sheet-metal caps at the ends and by self-closing oil-well covers.

Slotted feet cast integral with the stator frame facilitate accurate belt-tension adjustment. The assembled product is shown in figure 1, the stator in figure 2, and the complete disassembly in figure 3.

July, 1918

Price 20c.

The WIRELESS AGE

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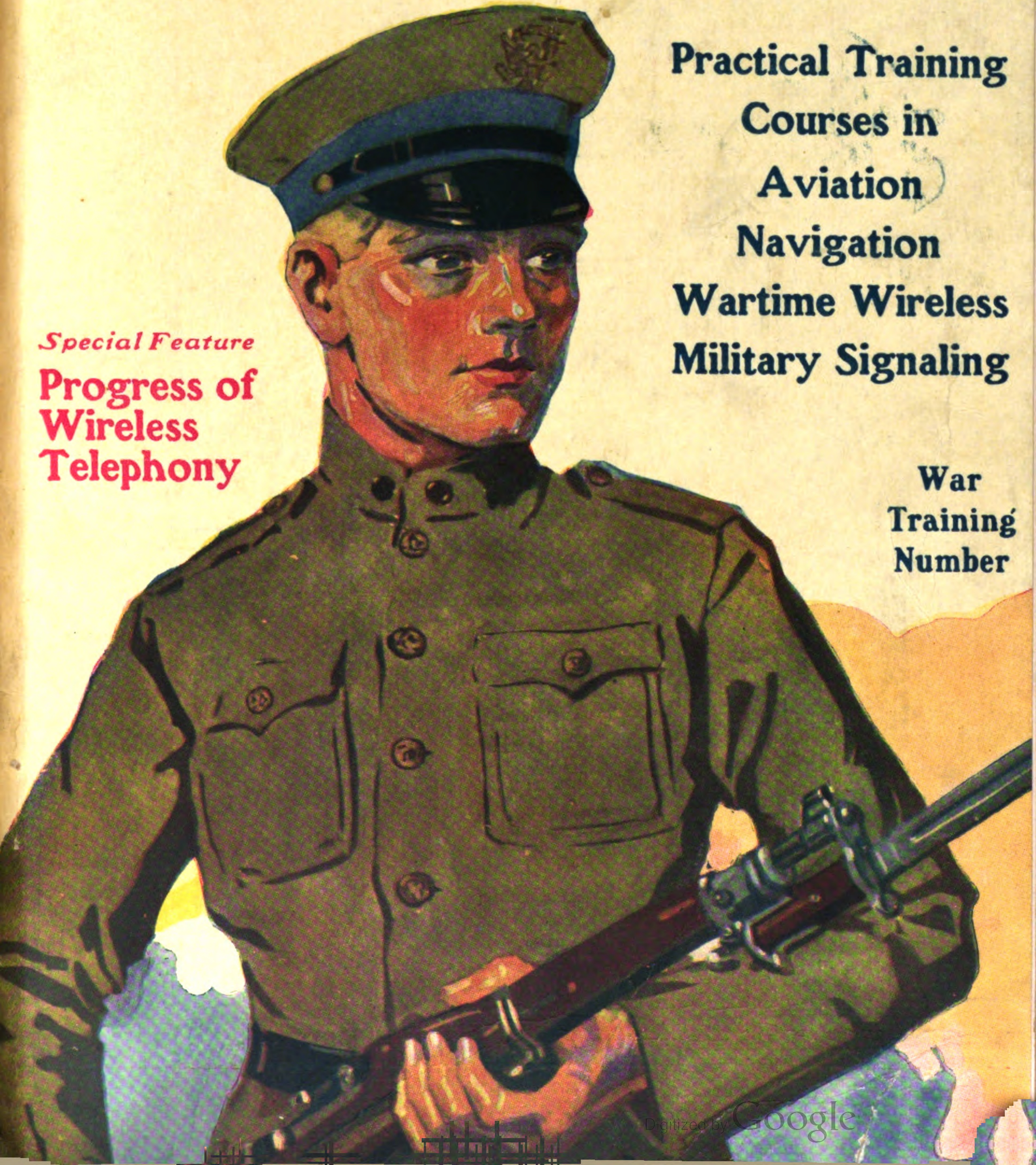

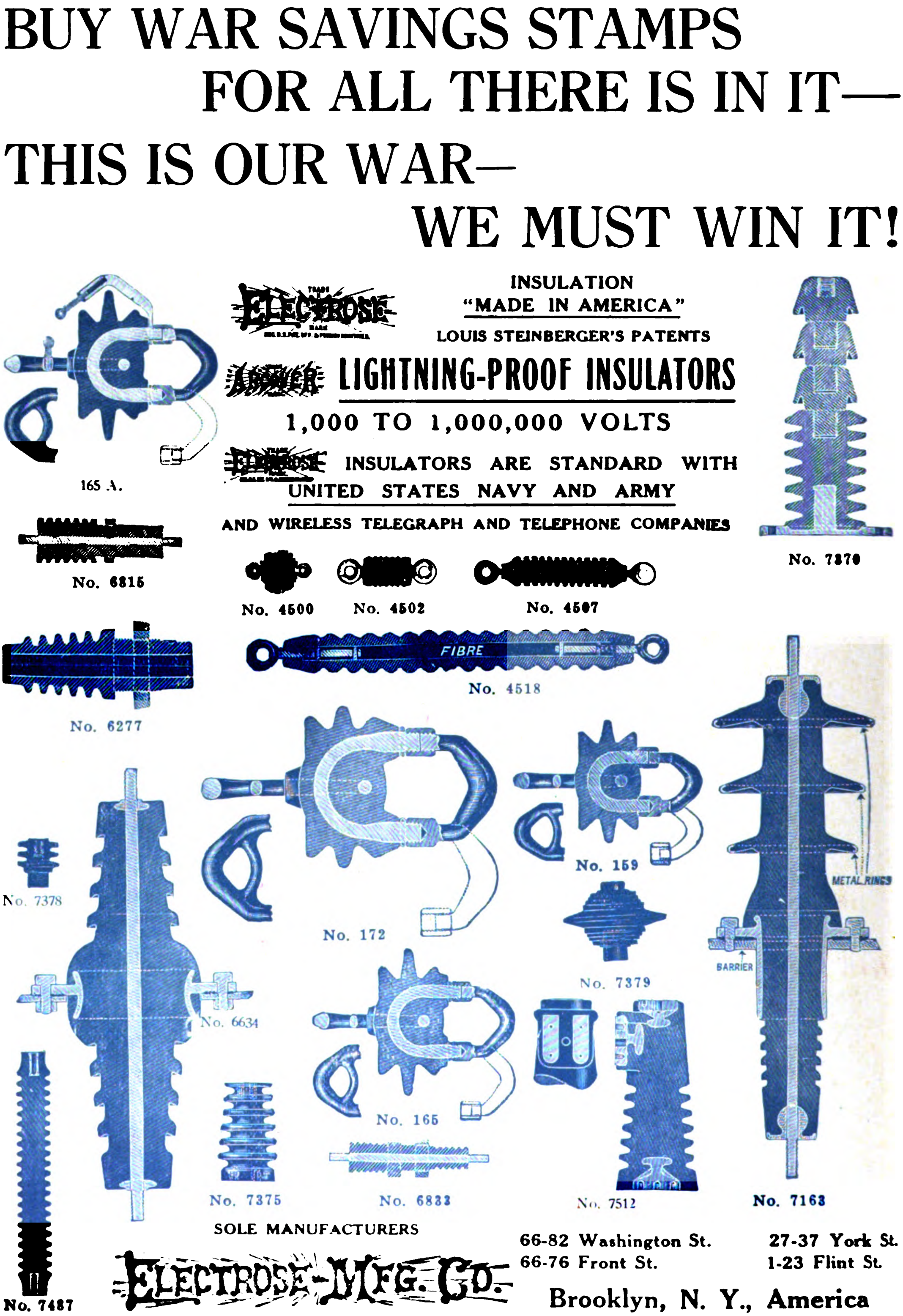
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JOHN BOTTOMLEY

Commercial wireless lost a pioneer from its ranks when John Bottomley, third vice-president, secretary and treasurer of the Marconi Wireless Telegraph Company of America, died in the Post Graduate Hospital, New York, on Sunday June 16th. Mr. Bottomley was in his seventy-first year.

Twenty years of ceaseless activity in the radio field are credited to the deceased, for it was in 1898 that he first met Marconi and took up the responsible task of introducing wireless telegraphy to the American world of commerce. In 1902 he became the active head of the American Marconi Company. At the time of his death he was vice-president and a director of the associated Marconi Telegraph-Cable Companies, treasurer of the Pan-American Wireless Telegraph and Telephone Company, treasurer and director of the Wireless Press and treasurer of the Marconi Institute. Mr. Bottomley had been a president of the New York Electrical Society and was an active member of the Engineers Club, vice-president of the Harlem Library, now incorporated with the Public Library, vice-president of the Harlem Dispensary and trustee of the Empire City Savings Bank.

He was born in Belfast, Ireland, in 1848, where he received his early education, later entering Queen's College. At the age of twenty-two he was placed in charge of a large exporting house, where he remained for ten years, coming to America in 1880. Here he studied law and was admitted to the Bar, being engaged in this profession up to the time when wireless claimed him.

Mr. Bottomley, who was a nephew of Lord Kelvin, the noted electrician, is survived by his wife, two sons and two daughters.

THE WIRELESS AGE

WORLD WIDE WIRELESS

An Opportunity for Patriotic Service for Stay-at-Homes

THERE are undoubtedly many men, and perhaps women too, who are intensely interested in winning the war but have not as yet found an opportunity to do their bit in the field where their efforts will produce the best results.

At the Marconi Company's factory, Aldene, N. J., which is the biggest plant of the kind in this country, great quantities and varieties of wireless apparatus are being manufactured and it is possible that a few of those who are interested in wireless and can interpret blue-prints and specifications might find desirable employment by addressing the Works Manager.

Swedish Radio Reaches Palestine

SWEDEN'S most powerful radio station, situated at Karlsborg, has been put into operation. Regular communication is now being conducted with Dutch Altengurs in Austria, and also with Tsarskoe-Selo. Wireless messages have also been exchanged with Spanish stations and with Constantinople. Word has been received that the Karlsborg station's messages have been read by a little station in Damascus, Palestine, although the Damascus station's plant is too weak to reach Karlsborg.

The masts, weighing only 25 tons each, are 684 feet high. They are insulated at four different places from the base to top and are erected with the bases embedded in black granite blocks, impregnated with paraffin. The aerials are 1,476 feet long and composed of 60 phosphor-bronze wires hung from steel tubes. The capacity of the station is increased by covering the territory between the masts with a phosphor-bronze wire netting.

Guatemala Acts to Prevent Secret Stations

LITTLE Guatemala throws in her lot with her big sister and declares that she stands by the United States. Guatemala is about as big as New York and has a population of about 2,000,000. Her action counts, as it will at least stop the establishment of German U-boat bases and wireless stations in her section of the Gulf and Pacific.

Mexican Link Established for Shipping Aid

A NEW wireless station has been established on the island of Lobos, off the cost of Tampico, largely for the purpose of affording the various petroleum companies facilities for communicating with their vessels while great distances at sea. This station is provided with some of the most powerful apparatus and will be able to communicate with the wireless sta-

tions at Mexico City, Tuxpan, Tampico, Vera Cruz, Progreso, Frontera, Mazatlan, Santa Rosalia, La Paz, Queretaro, Monterrey, Saltillo, Torreon, and by way of Havana with various stations in the United States.

War Calls Off Patent Litigation

AT the request of the Navy Department, litigation in the United States Circuit Court of Appeals in San Francisco, involving the Marconi Wireless Telegraph Company's patents has been ordered suspended for the duration of the war. At the request of Attorney Samuel Knight, representing the Marconi company, and Hiram Johnson, Jr., appearing for the Kilbourne & Clark Manufacturing Company, which Marconi charges with infringement of patents, the cases were taken from the calendar. Two days, May 22 and 23, had been set aside by the Circuit Court judges for hearing arguments in the cases. The Government now is using the Marconi patents.

Direct Communication With France by New U. S. Station

WITHIN the next few weeks the United States government will put into operation one of the most powerful wireless stations in the world. Not content with this, the government will build outside of the United States powerful wireless stations of a like capacity so that they can communicate. All of the stations will be placed under heavy guard of armed soldiers and will be surrounded by barbed wire entanglements.

The first station is being rushed to completion at Greenberry Point, on the Chesapeake Bay, across a small body of water from Annapolis and the United States Naval Academy.

Four giant towers, each 600 feet in height and situated 850 feet apart, are completed. Workmen are placing the wires and otherwise finishing off the great steel towers which will flash forth messages to the ships of the navy and to the expeditionary forces.

The new station, when completed, will cost approximately $750,000. The equipment will cost an extra $100,000, making a total cost of $850,000.

Western Railroad Operation Largely Governed by Marine Radio

TO avoid congestion at seaboard and to insure that the right cargo is at the right pier at the right time, American railroads east of Chicago virtually will be operated by wireless.

Boats returning from Europe do not announce their sailings. Their whereabouts and approximate time of docking is not known until within forty-eight hours of arrival, when it is wirelessed in. In order that docks may not be cluttered with supplies, congesting movement and delaying loading, materials will move to ports only as needed, and each shipment will be made to a definite pier of a definite port, to be loaded on a specific vessel of a certain tonnage.

For instance, "Bertha B," wirelesses on Wednesday that she will be in Friday morning. Shipping officials by wireless assign "Bertha B" to dock at a certain pier, scheduled to be clear at her time of arrival. They determine the vessel should carry 3,000 tons of shrapnel to a French port.

Orders are immediately wired shrapnel factories, where known supplies are held, to rush 3,000 tons to the proper pier of the proper port by Friday morning.

Trains to deliver this are made up and rushed through on express schedule, all passenger and ordinary freight movement being side tracked to give them right of way.

When "Bertha B" gets in she finds her cargo ready. While stevedores are working at double quick to stow her new cargo, colliers draw alongside and pour her bunkers full of coal. In half the normal time in port she is loaded, coaled and off again on another trip through the submarine zone.

Marconi Awarded Franklin Medal

THE final meeting, marking the ninety-fourth season of the Franklin Institute, was held in Philadelphia May 15th. Dr. Harry F. Keller, on behalf of the Committee on Science and the Arts, introduced Count V. Macchi De Cellere, who accepted the Franklin Medal awarded to Signor Guglielmo Marconi in recognition of his brilliant inception and successful development of the application of magneto-electric waves to the transmission of signals and telegrams, without the use of metallic conductors, known as wireless telegraphy, for Signor Marconi, who was unable to be present.

The Franklin Medal is awarded annually to those workers in physical science and technology, without regard to country, whose efforts, in the opinion of the Institute, have done most to advance the knowledge of physical science or its application.

Wireless Warnings of Submarine Raids Sent in Advance

CONTINUING their attacks on vessels headed for mid-Atlantic American ports, German U-boats found another victim on June 6th, when the British steamship Harpathian, 4,500 tons, was attacked and sunk 100 miles east of the Virginia Capes. All members of the crew were saved.

The sinking of the Harpathian brought the number of vessels attacked by submarines off the Atlantic coast since May 25 to fourteen so far officially identified as having been sunk or damaged and brought the total tonnage lost to 32,237 in eleven days of submarine operation. The tanker Herbert L. Pratt, of 7,200 tons, was, however, raised, so that the net loss is 25,037 tons; but the loss of life has not been heavy, and so far no transports have been touched.

Assistant Secretary of the Navy Roosevelt has disclosed the very interesting fact that he had an advance tip on the possibility of the arrival of several submarines off the American coast, that this information was of a very definite character, and was acted upon by the navy in advance. Mr. Roosevelt did not consider it wise naval policy to disclose full particulars regarding the source or detailed character of the information the Navy Department had received. Acting on it the Navy Department had begun a lookout on a more intensive scale for submarines, and had also warned vessels along the coast or approaching the coast. These warnings were sent to Porto Rican, Cuban, and other Caribbean ports, as well as to the vessels at sea and to certain port officials. Vessels had been warned by wireless several days before the U-boat raids began.

The number of schooners sunk is accounted for by the fact that without carrying receiving apparatus schooners were unable to pick up the radio warnings spread by the navy; also by the slower speed of the schooner. But that many passenger vessels and steamers were saved, and escaped vessels have been reaching American ports for a week, was probably due to the fact that they had been forewarned.

Carolina's Wireless Man Tells Experiences in Submarine Raid

ERWIN W. VOGEL, the eighteen-year-old boy who was wireless man on board the Carolina, is constructed on the plan of the hour glass in that he is wide at the shoulders, lean at the waist and amply provided with sand. There were shells banging all around the vessel when he sent her distress call out on June 2nd.

"I had been asleep," he says of his experience, " and was just dressing to go on duty Sunday evening when my assistant, Harry Werner, sent a messenger to me with word that a submarine was shelling a schooner somewhere and that he had caught the schooner's signal. To be frank about it, I was just half way into my pants. I pulled them on the rest of the way and dived on deck in my bare feet and undershirt.

"As soon as I got the cups to my ears I caught the schooner's signal over again and learned that she was the Isabel Wiley, in latitude 38:07, longitude 75:10. I sent Werner to warn the captain, and the ship's course was changed right away.

"I had a snack brought up to me and was sitting eating it and still listening in when at 5:30 a shell plopped across our bows. I squinted out and saw the sub hauled right alongside. I could hear the passengers bundling up on deck. I yelled to Werner to go find out our position from the captain or one of the officers and sent our first call out, giving our name and the fact that the Dutchmen were shooting. By the time I had sent it twice two more shells had gone whistling over us.

"It wasn't my business to figure out whether we were to be allowed to leave the vessel or whether we were to be sunk outright. My job was to send. I kept right on shooting out the distress message and yelling for somebody to give me the position.

"Presently Werner came in and said that the Dutchmen had hailed us by megaphone and said I must stop sending. I told Werner that I wasn't taking orders from any skipper but my own and to get me my orders from Capt. Barbour. He disappeared, and after I had sent the signal once or twice over again he came back with the captain behind him.

"You can stop sending, 'Sparks,' said the captain. The cups were still at my ears and I didn't hear him perfectly, so he shouted it over again, and added, 'that is an order.' Then I stood up from my chair and stepped away from the machine and the captain directed me to leave the house in case a shell might find its way in on us.

"But even after I had come out on deck a few more shells were sent sailing over the ship, I imagine, to knock out the aerials if possible. However, they cut that out by the time the decks were lined with our passengers and crew.

"It developed after we were in the boats that the shelling had been done principally to hurry us and without intent to hit us. One of the sub's officers said so. However, I had had the satisfaction of hearing from Cape May just before I quit my job and knew that they knew ashore what had happened to us.

"None of the Germans boarded the Carolina before she was sunk. All they said to us was communicated through their megaphones. When all hands were out of the Carolina the sub hove close in and poured about seven shots into her at the water line. They quit when she began to settle. It was an hour and a half by the captain's watch—he and Werner and I went away in the same boat—when the Carolina finally dived under. Her boilers blew up just before she sank and she went down by the head."

Vogel is a New Yorker and has been a wireless operator two years. His profession has had a fascination for him since he was a child and when he was a schoolboy he installed an amateur's set on the roof of his home. He studied at the Marconi Institute, graduating two years ago.

Operator Doherty Dies as Hero of the Key

MISINTERPRETATION of fog signals is believed to have been the cause of the collision between the City of Athens, the coastwise liner, and the French cruiser off Atlantic City early in the morning of May 1st, causing the loss of sixty-eight lives.

F. J. Doherty, the wireless operator, stuck to his post, vainly trying to send a call for help. Captain A. G. Forward, commander of the liner, three times ordered Doherty to leave his post and save himself, but the operator refused. He was working the key as the City of Athens sank.

Progress of Wireless Telephony*

By Elmer E. Bucher

Director of Instruction, Marconi Institute

THE vacuum tube is an unusually versatile device. Based upon Fleming's original discovery of the mobility of electrons under the influence of positive and negative charges, it is perhaps susceptible to a greater number of practical applications than any other type of oscillation detector or current amplifier heretofore devised. For example, it may be used as a detector of discontinuous waves in radio telegraphy as an amplifier of incoming radio telegraph signals, or as a self-heterodyne for the detection of continuous oscillations through the phenomenon of beats. It may also be employed to

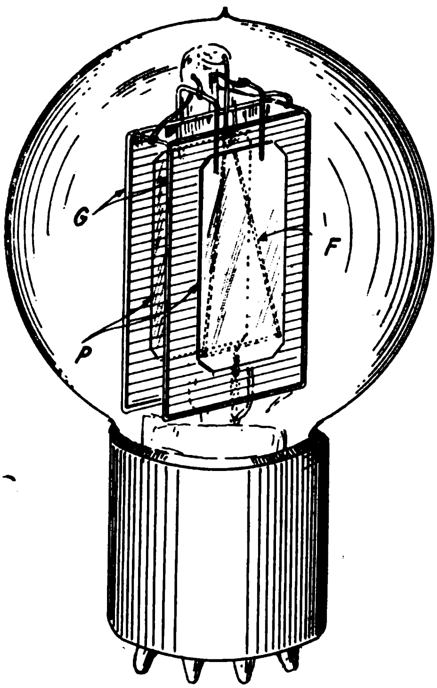


Figure 1—A typical three-electrode tube

amplify land-line telephonic signals, or by suitable connections it will amplify the output of a radio frequency alternator. The tube is in fact applicable to the amplification of a variable E. M. F. of any wave form.

One of the important applications of the tube is its use as a direct generator of radio frequency currents for either wireless telegraph or telephone communications. Not only does it constitute a generator of simple construction, but through its inherent operating characteristics it approximates an ideal modulator of radio frequency currents at high powers for radio telephony, functioning in a most direct and simple manner.

A modern vacuum tube may consist of two or three main elements—a filament and a plate or a filament, grid, and plate. Considering the three-electrode tube, the function of the filament in brief is to emit electrons, that of the plate to concentrate these electrons in a direct path to act as a carrier of local currents, and that of the grid to act as a controller of the electron cur-

* From "Vacuum Tubes in Wireless Communication," now in press.

(C) Int. Film Svce.

Communication with aircraft is graphically shown in this remarkable picture of a Serbian wireless outfit concealed in the woods. The receiving station is located at the base of the stone hut and the soldier is actively engaged in taking down a message from the aerial observer. The soldier on the extreme right is telephoning the fire corrections to the artillery while the two in the middle distance are laying out the white strips in the form of a T, as a signal to the aviator above

rent. All three elements may be made of tungsten, or the filament may be of platinum, the grid of tungsten, and the plate of nickle. Other metals are often employed.

A typical three-electrode tube is shown in figure 1, where F is a triangular shaped platinum filament, G the grid made up of a number of turns of fine tungsten wire, and P a flat metallic plate of copper or nickle. The filament is incandesced by a four to six volt storage battery, and the plate is charged to a positive potential by a battery of sixty volts* or more.

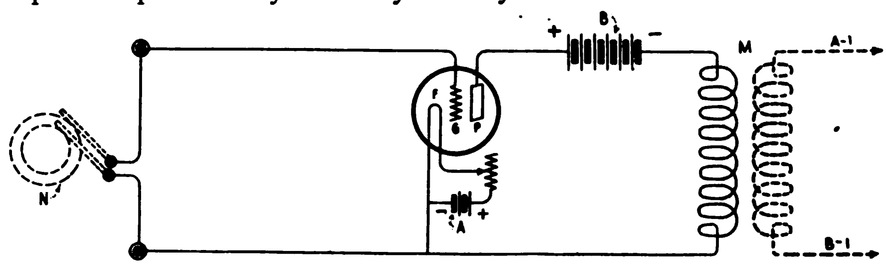


Figure 2—Diagram showing the input and output circuit of a vacuum tube

Before considering the circuits of the vacuum tube as a generator of radio frequency currents, certain problems involved in the art of wireless telephony will be discussed. In general, wireless telephone conversations are transmitted by a radio frequency wave motion termed the carrier wave. The carrier wave is modulated at an audio frequency (or speech frequency) by a microphone transmitter like that employed in land-line telephony. Any undamped wave transmitter and any type of oscillation detection giving quantitative response may be employed, provided the usual magnetic telephone is the current translator.

Consider for a moment a wireless telegraph transmitter which generates a steady wave train of continuous amplitude. If a radio receiving set containing a simple rectifier and a telephone is tuned to the transmitter, pulses of direct current in rapid succession traverse the telephone windings, but produce no sound. But if the amplitude of the radiated energy be modulated at an audio or vocal frequency by means of a microphone, the amplitude of the rectified current will be varied at a vocal frequency accordingly. Hence, the vibrations of the telephone diaphragm will follow those of the microphone diaphragm at the transmitter. The audio frequency variations occasioned by the microphone generally occur at rates from 100 to 2,000 per second, the mean average being approximately 1,000 per second. This average has been termed "mean speech" frequency.

The great problem heretofore in radio telephony has been the difficulty of modulating the powerful currents flowing in the transmitter aerial by the usual microphone, which at its best can only handle approximately one-half to one ampere of current. Owing to the imperfections of the microphone, particularly its limited current carrying capacity, a continuously operative radio telephone system was not produced until the advent of the vacuum tube.

In the earliest radio telephone systems, in order to modulate the antenna current, a number of microphones were connected in parallel and then in series with some part of the antenna system, or in special circuits associated inductively or conductively with the antenna system; but owing to the "packing" (coherence of the carbon granules) of the microphone and the difficulty of overheating, only very small powers could be employed.

Various types of high power microphones have been constructed, but they cannot be said to have satisfied the demands of modern engineering, i. e., that they be continuously operative.†

* Some tubes require only 25 volts in the plate circuit.

† The problems of wireless telephony are treated in detail in "Radio Telephony," a recently published book by Dr. A. N. Goldsmith.

Experiments have been made with the microphone connected in the field circuit of a D. C. generator supplying current to an arc generator; or in a similar way, to alter the field excitation of a radio frequency alternator. But such systems have been only partially successful because of the small current carrying capacity of the microphone and the consequent limited degree of modulation of the antenna current.

It may be stated in general that the systems of radio telephony hereto-

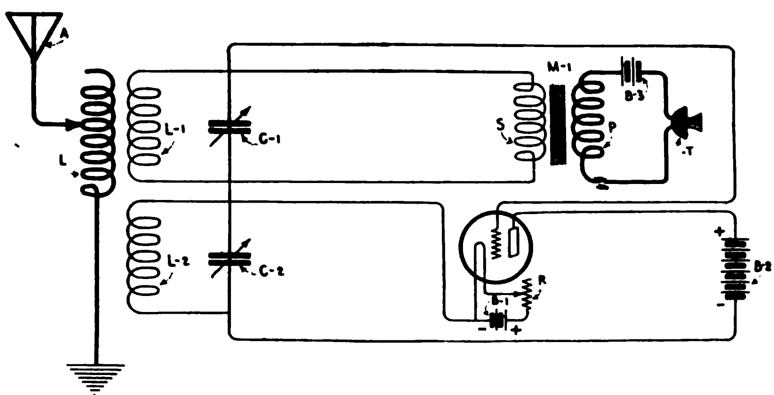


Figure 3—A simple wireless telephone circuit

fore proposed contemplated the generation of a carrier wave above the limits of audibility and the modulation of either the amplitude or the wave length at speech frequency. In some systems one or the other function is performed individually, and in others both occur to a limited degree simultaneously.

The vacuum tubes have offered a practical solution of this problem for, as already mentioned, they can be employed to generate radio frequency alternating currents of any desired frequency. And beyond this (as the grid potential—plate current characteristic—of a properly constructed valve indicates) a very slight change in the grid potential will cause a relatively large variation of the plate current. Hence, if a vacuum tube is connected up for the production of continuous oscillations, and a microphone and a battery connected inductively, conductively, or electrostatically to the grid circuit, the grid potential will rise and fall in accordance with the sound modulations of the human voice, and the amplitude of the radio frequency carrier wave will be modulated at vocal frequencies.

The three-electrode vacuum tube may be said to consist of two principal circuits, the input circuit and the output circuit. They are shown in figure 2. Connection to the filament F and the grid G constitutes the terminals of the input circuit. The terminals A-1, B-1, of the transformer M may be said to constitute the output circuit, or at least the portion of the output circuit from which the amplified energy may be withdrawn. The filament F when heated to incandescence emits electrons which are drawn to the plate P by charging it to a positive potential through the battery B. Current from the battery flows from the plate P to the filament F, and returns to the negative side of the battery.

The strength of this current is limited in two ways: first, by the electronic emission of the tube, and second, by the so-called space charge. It is found that the field of electrons between the filament F and the plate P constitutes a negative electrical charge, and when this attains a certain value, it will tend to push back the electrons given off by the filament. It has also been proven that if the grid G is charged to a negative potential by an external E. M. F. the space charge will be increased and consequently the flow of current from the battery B will be reduced. In other words, the negative charge on the grid acts to obstruct the flow of electrons from F to P. If, on

the other hand, G is charged to a positive potential, the flow of electrons is accelerated, and consequently the strength of the plate current fed by the battery B increases. Hence, if an alternating E. M. F. such as that supplied by an alternator M be impressed upon the grid and filament (the input circuit) an amplified alternating current can be taken from the terminals A-1, B-1. In this case, the valve is simply employed to amplify the output of the alternator, the additional energy required for amplification being furnished by the battery B.

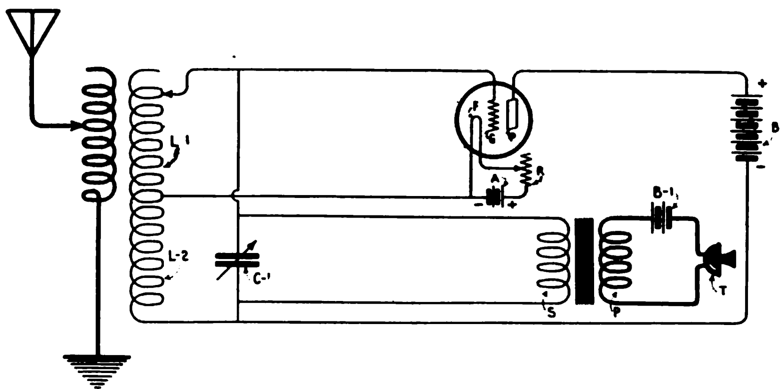


Figure 4—A suggestive circuit of same type as figure 3

It can be shown that a very small amount of energy applied to the grid circuit will release a considerably greater amount of energy in the plate circuit, and it ought to be self-evident that if the plate circuit is coupled back to the grid circuit, the alternator M can be dispensed with and the entire system set into a state of self-oscillation. This is precisely what occurs in a circuit properly devised for the use of the vacuum tube as a generator of radio frequency currents. If the input and output, or grid and plate circuits respectively, are coupled magnetically or electrostatically or in both ways simultaneously, enough energy can be fed back from the output circuit to the input circuit to keep the system in a state of self-oscillation.

The tube and its associated apparatus connected in this way is often termed a regenerative system, and the tube is sometimes termed a self-oscillator. Suggestive circuits will follow.

Simple Wireless Telephone

A diagram typifying this system of connections is shown in figure 3. Here the grid and plate circuits of a three-electrode tube are coupled magnetically at the transformer M, the grid circuit comprising the coil L-1, the condenser C-1, the grid G, and filament F; and the plate circuit the coil L-2, the condenser C-2, the battery B-2, and the filament F and plate P. The grid and plate circuits are tuned principally by the condensers C-1 and C-2, although the frequency can be changed by coils L-1 and L-2 as well. The antenna circuit is indicated at A, L, E, it being coupled to either the plate coil L-2 or the grid coil L-1. To set this system into a state of self-oscillation, either the potential of the grid circuit or the plate circuit must be suddenly changed. For example, if the E. M. F. of the battery B-2 is varied by any means whatsoever, a change of flux will occur in the coil L-2 which will induce an E. M. F. in the coil L-1, setting the circuit L-1, C-1, into oscillation at a radio frequency. The potential of the grid G will vary at a similar frequency and it will act to increase and decrease the strength of the plate current furnished by the battery B-2 at the same frequency. Since the plate circuit is tuned by L-2, C-2 to this frequency, the current in the plate circuit rises to considerable value. The entire system is now in a state of oscillation at a

radio frequency which can be changed by simultaneously varying the condensers C-1 and C-2. Current can then be withdrawn from the circuits of the valve into the antenna system from which part of the energy is radiated in the form of electro-magnetic waves.

The amplitude of the radiated energy can be varied at speech frequency by means of the induction coil M-1, connected to the microphone T and the battery B-3. By proper design of the induction coil, several volts may thus be impressed upon the grid, which will cause amplified variations of the current in the plate circuit, resulting in a very great modulation of the antenna current. Valves employed for the generation of radio frequency at high

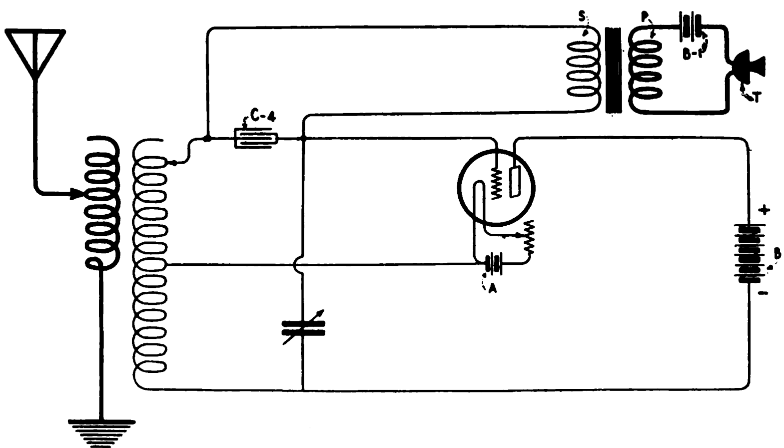


Figure 5—Method of connecting microphone and its induction coil to the grid circuit

powers may have plate potentials up to 2,000 volts or more. In order to secure the correct operating characteristic, the grid is held at from 150 to 300 or 400 volts negative potential by means of a series grid battery (not shown).

It should be understood that figure 3 is simply a suggestive circuit. It may be re-drawn as in figure 4, coils L-1 and L-2 being considered as one long coil tapped at the center to the filament. A single condenser C-1 can be used to tune the plate and grid circuits simultaneously. The microphone and its induction coil may be connected as in figure 3, or in another way as in figure 5, where a large condenser C-4 is connected across the secondary terminals of the induction coil and in series with the inductance of the grid circuit.

There are many combination circuits for wireless telephony in which the three-electrode vacuum tube may be employed in one way or the other. For example:

(1) A number of bulbs connected in parallel may generate the requisite radio frequency current and one or more additional bulbs including a microphone transmitter may be used to vary the output of the "power bulbs" by variation of their grid potential.

(2) The radio frequency current for the carrier wave may be generated by a radio frequency alternator and modulated by connecting a three-electrode valve at some effective point in the antenna system.

(3) A battery of "power" vacuum tube bulbs may be employed to amplify the output of a small radio frequency alternator and the grid potential varied at mean speech frequency by additional bulbs including in their grid circuit an induction coil and a microphone.

(4) A battery of tubes controlled by a microphone may vary the field excitation of a radio frequency alternator.

Round's Wireless Telephone System

A few examples of proposed systems will be described. The first system to employ the vacuum valve as a source of oscillations for wireless telephony was that developed by H. J. Round of Marconi's Wireless Telegraph Company, Ltd., which is shown in figure 6. It will be noted in this diagram that the grid and plate circuits of a vacuum tube are coupled at L-3 and L-4, the antenna being coupled to the grid circuit at L-1. The plate battery B-2 varying from 500 to 2,000 volts is shunted by the condenser C-2. Four

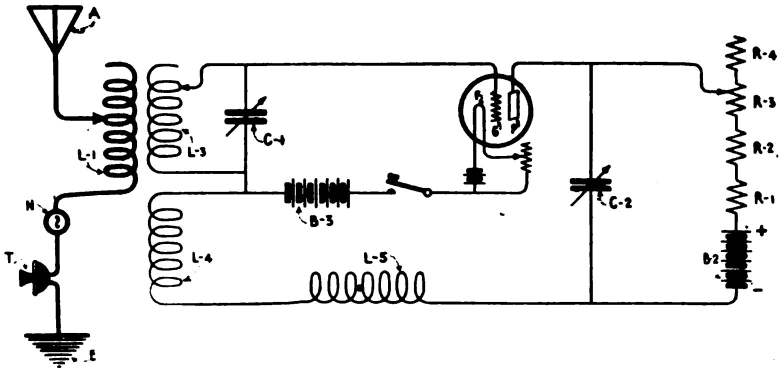


Figure 6—Circuit of first wireless telephone system to employ the vacuum valve as a generator of radio frequency currents

resistances, R-1, R-2, R3—of 500 ohms—and R-4—of 10,000 ohms—are connected in series with the plate battery.

The filament battery B-1 is an 80 ampere hour 6-volt cell, and the grid battery B-3 has a voltage of approximately 500 volts. A microphone T is connected in series with the antenna circuit as well as a small glow lamp N, which is employed to indicate conditions of resonance between the generating circuit and the antenna circuit.

The entire system is set into oscillation by opening and closing the key K connected in the grid circuit. Resonance is established by careful adjustment of condensers C-1 and C-2. By further adjustment of the reaction coupling and by tuning the antenna circuit, the small glow lamp N, will light to full brilliancy. This indicates that the antenna circuit is in a state of oscillation. When the transmitter T is spoken into, the radio frequency wave is modulated at speech frequency and response will then be secured at the receiving station. Note should be made of the fact that the microphone is connected in the circuit where it is perhaps the least effective, but later circuits developed by Round show the microphone connected to the grid circuit. With the connections of figure 6 distances up to 50 miles were readily covered.

Hund's Method of Radio Frequency Modulation

A system for controlling the carrier wave at an audio or vocal frequency suggested by August Hund, is disclosed in figure 7. In this system, the antenna oscillations are modulated at vocal frequency by a three-electrode vacuum tube. The radio frequency current for the carrier wave is generated by the vacuum tube V, the grid and plate circuits being coupled together as usual for the generation of radio frequency currents. By coupling L-2 to L-1, currents of similar frequency are induced in the antenna circuit.

The antenna system further includes the coil L-3 which may have from 6 to 15 microhenries inductance. The terminals of L-3 are connected to the plate P-1 and P-2 of the three-electrode bulb V-1.

The filament F-1 is lit to incandescence by the battery B-1 and the potential of the grid to filament varied at speech frequency by the microphone T through the iron-core induction coil P-1, S-1. The potential of the grid

in respect to the filament can be maintained at the most satisfactory value by battery B-3 and potentiometer P. The grid normally is held at a fairly high negative potential so that no currents leak around L-3 through the valve F-1, G-1, P-1; but when the microphone T is spoken into, the valve becomes conductive at vocal frequencies; one half cycle of the carrier wave leaks through the conduction path from P-1 to F-1, and similarly the other half cycle through the conduction path from P-2 to F-1. Thus energy is withdrawn from successive cycles of the carrier wave in accordance with

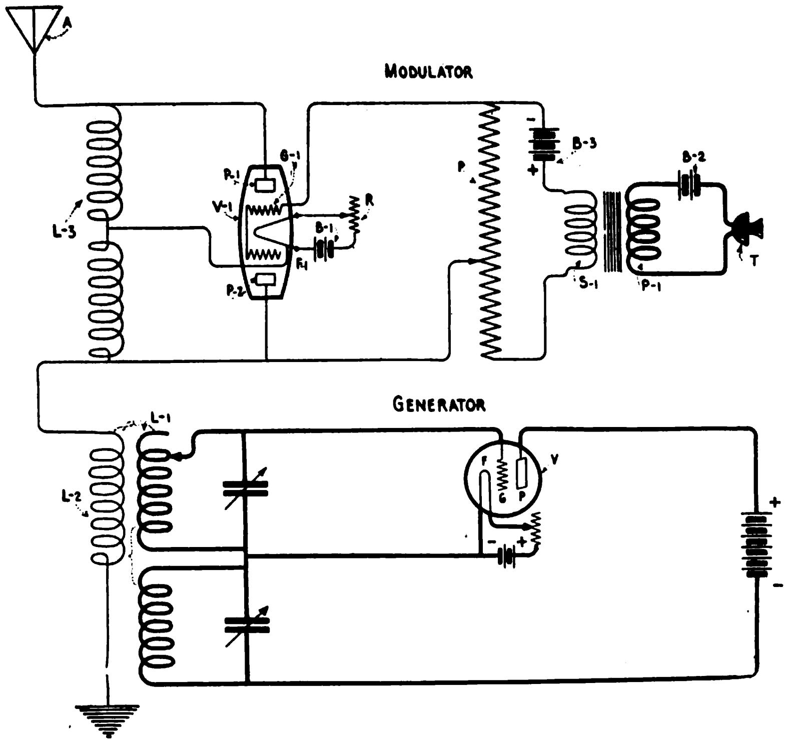


Figure 7—Hund's system for controlling the carrier wave at audio or vocal frequency

the vocal wave impressed upon the grid by the microphone T and the transformer P-1, S-1. In summary, the grid potential is modulated by the microphone, and the radio frequency currents leak from plates P-1 and P-2 to filament F-1. The antenna oscillations are damped out at speech frequency.

Obviously, two valves might be employed to secure this leakage.

Englund's Wireless Telephone System

It has been established that if the frequency of the carrier wave in wireless telephony is of constant amplitude and F cycles per second, and it is modulated at a vocal frequency f by a microphone, there will be radiated into the ether a complex wave which is made up of three component frequencies F, F-f, F + f. It is evident that the unmodulated component of the antenna current F since it does not contain the signal frequency f, need not be present in the antenna, but it may be supplied by an auxiliary source at the receiving station. Hence, if by any means the carrier frequency F can be eliminated, except as at such time that the wireless telephone transmitter is spoken into, a considerable wastage of energy is prevented, and furthermore, the carrier frequency F will not interfere with the operation of other stations in proximity.

In Englund's proposed system,* shown in figures 8 and 9, this phenomenon

* It cannot be said that systems outlined in these diagrams have attained the stage of practical commercial application. They are merely published to indicate the general trend of experimentation.

Press Ill. Svce.

The erection of wireless antennae in unexpected places is well illustrated in this view of Canadian signalmen in Flanders using a shattered tree to support an aerial of the umbrella type. The road repairs which are being made nearby and the flat nature of the country are details of interest to the Americans who are soon to experience the identical service conditions in providing radio communication for our army. Reports from France indicate that the use of the umbrella type aerial, such as is here shown, has now been definitely discarded and the horizontal, or T type, almost universally used. Most of the communication by radio being over short distances and on low wave lengths, many interesting problems are encountered and amateur experience found of particular value

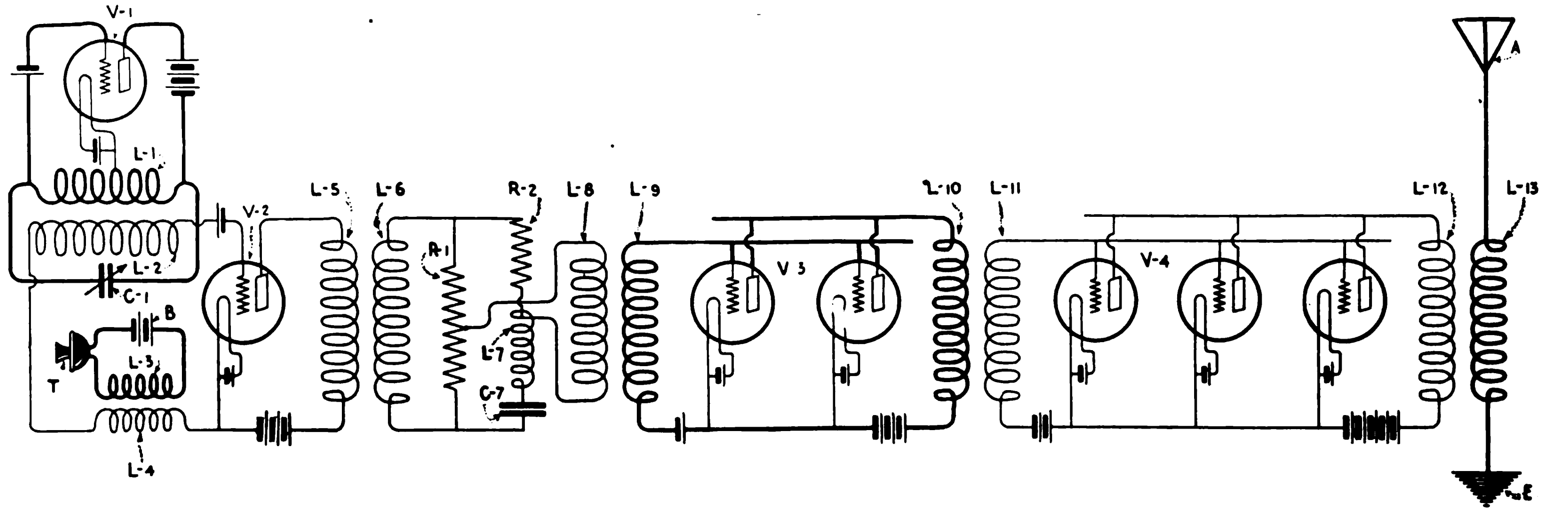


Figure 8—Fundamental circuits of a high power radiophone transmitter wherein vacuum tubes are employed to generate and to modulate radio frequency currents. The outstanding feature of this system is that the antenna does not radiate until the microphone is spoken into.

The radio frequency currents are first generated by a single three electrode tube, and then modulated by a microphone. The modulated currents are in turn amplified by a set of "amplifier" bulbs and further increased in strength by a set of "power" bulbs. The plate circuits of the latter are supplied with energy from a direct current dynamo. This system is credited to Englund.

is taken into consideration and means have been devised whereby the antenna circuit A, L-13, E, is traversed by radio frequency currents only when the transmitter "T" is spoken into. From this diagram, the student receives some hint of the fundamental circuits of a long distance wireless telephone system in which vacuum valves are employed not only to **generate the radio frequency current but to modulate it at speech frequency as well.** It is to be noted first, that the vacuum tube V-1 called the **master oscillator** has its plate and grid circuits coupled for the production of radio frequency currents through the coil L-1 and the condenser C-1, that is, the grid and plate

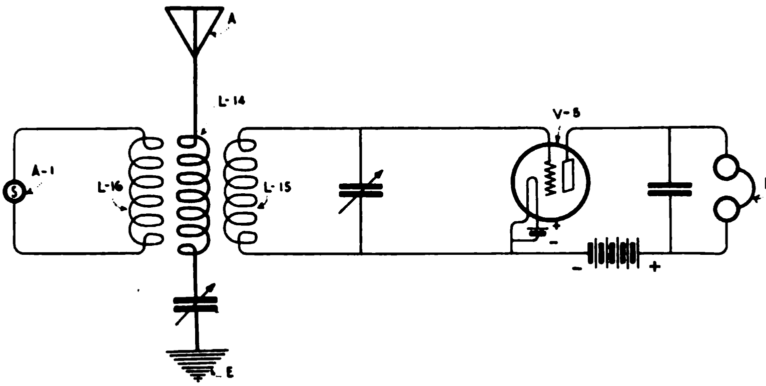


Figure 9—Radiophone receiving system for economy of energy and improved quality of received signals

circuits are coupled in such a way as to set the circuits of V-1 into oscillation. Coupled to L-1 is the secondary coil L-2 which in turn is connected to the grid and filament of another vacuum tube V-2 termed the **"modulator."**

The output circuit of the "modulator" bulb is coupled to L-6 through L-5. The circuit of L-6 in turn contains a bridge consisting of resistances R-1, R-2, inductance L-7, and condenser C-7. Tapped across this bridge is the inductance L-8 coupled to L-9, the terminals of which in turn are attached to the grid and filament (the input circuit) of a battery of tubes V-3.

By properly balancing the bridge, no current flows through L-8 at the carrier frequency F, but currents of a frequency differing from that of the carrier frequency destroy the balance according to the frequency of the vocal currents generated by the human voice. The modulated currents are then amplified by the vacuum tubes V-3 connected in parallel.

The output circuits of these bulbs are in turn coupled to the grids and filaments of the battery of **power bulbs,** V-4, of which there may be any number connected in parallel. The plate circuits of V-4 may be fed by a direct current dynamo or a large storage battery. Their output circuits are in turn connected to the antenna system at L-12 and L-13.

Beginning at the extreme left-hand part of the drawing, figure 8, a circuit will be seen containing the microphone T, a battery B, and an induction coil L-3, L-4, which is coupled to the input circuit of the **modulator bulb V-2.** The radio frequency current modulated by the microphone unbalances the bridge network above mentioned and the resulting currents are amplified through the batteries of bulbs V-3 and V-4.

The oscillator V-1, of course, can be replaced by a small radio frequency alternator. Very feeble currents flowing through microphone T can control antenna current of many kilowatts, thus greatly increasing the distances over which wireless telephony can be carried on.

Since the carrier wave of frequency F has been eliminated by this process, it must be supplied at the receiving station. The diagram, figure 9, shows a radio frequency alternator A-1 (for which may be substituted a vacuum

valve connected up for the production of radio frequency oscillations) coupled inductively to the antenna system at L-16 and L-14. A vacuum valve V-5 is employed for purposes of detection. It is inductively coupled to the antenna circuit L-15.

The inventor claims that in addition to the elimination of the waste of energy by this system there is a slight improvement in the quality of received signals due to the elimination of the frequency F.

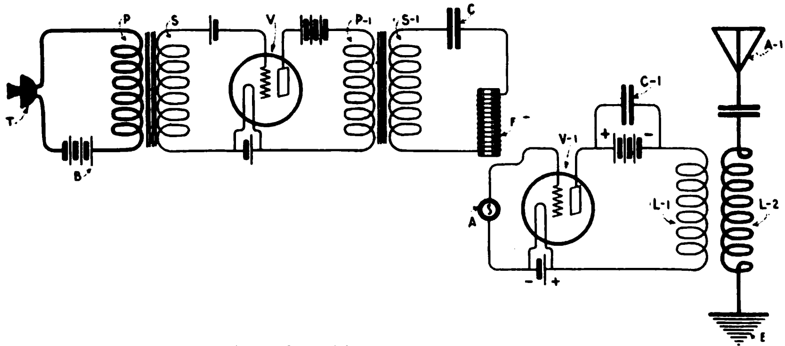


Figure 10—Radiophone transmitter in which the antenna does not radiate unless microphone operates

Carson's Proposed Wireless Telephone System

Another system has been disclosed by John Carson in figure 10, in which the antenna does not radiate except when the microphone is spoken into. It is to be noted in this diagram that the field current of a radio frequency alternator A is modulated at vocal frequencies by a mircophone T the currents of which are amplified by a vacuum tube V. The field windings F of the alternator are thus excited at speech frequency and the amplitude of the radio frequency current generated by A varied accordingly.

The complete microphone circuit includes the **transmitter T**, the **battery B**, and the **induction coil P, S.** Winding S is connected to the **grid** or **input** circuit of a three-electrode valve V, the **plate** or **output** circuit of which includes the primary winding of an induction coil P-1 coupled to the secondary winding S-1. The secondary circuit includes the condenser C and the field winding of the alternator F. The armature of the alternator A is connected to the grid or input circuit of the tube V-1 whose plate circuit C-1, L-1, may be fed with direct current from battery or direct current dynamo D. This tube, repeats and amplifies the radio frequency currents impressed upon its input circuit and the oscillations of the output circuit are transferred to the antenna through the coupling L-1 and L-2. The impedance of the circuit S-1, C, F to the vocal currents is reduced by condenser C.

In summary, the modulated currents set up by the microphone circuit T, P, B are amplified by bulb V, and a fluctuating current circulates through field winding F which varies the output of the radio frequency alternator A at a vocal frequency. A current, the reproduction of the signaling current, therefore flows in the antenna which radiates only when the microphone is in operation. The amplitude of the high frequency wave radiated from the antenna is directly proportional to the low frequency signaling wave, hence the telephone diaphragm at the receiving station is deflected at vocal frequencies.

In ordinary systems, as we have already mentioned, there is a continuous radiation in the form of an unmodulated carrier wave even when the transmitter is not spoken into. The transmission of this wave, besides involving a waste of energy, constitutes a serious bar against the operation of duplex systems.

(To be continued.)

Before We Go Overseas

The Personal Observations of an Army Non-Com on Training in the Signal Corps

By Sergeant Frank A. Rose

MY experiences on the border in the Big Bend country with the Machine Gun Company, were very interesting indeed, but in the shadow of all that is happening now, they pale into insignificance. The Signal Corps at Marfa had a small unofficial radio receiving station which was capable of receiving from Juarez, in Mexico, far to the Northwest, and San Antonio some 400 miles to the East, and from some other high powered stations. The whole Big Bend was covered with a network of single wires, as the basis of signal work in that country was a simple single wire buzzer system. The ground was so dry that the wire could be left lying on the ground with impunity, and, indeed, was so left at many points, for days at a time. Occasionally, a band of roving Mexicans would cut out a portion just for experimental purposes; but as a whole the lines of communication were in working order most of the time.

By the time the Great War is ended, when we may have to go back on the border again, it is to be expected that there will be wireless stations at every post or camp in the Big Bend, for through them lots of trouble and time, and upon many occasions, lives would be saved. An airplane patrol would spare men and horses long, weary, dusty, hot, dry rides, too, and would permit the close watching of roving bands of Mexicans with a few planes from the main posts two hours daily in the air. The Curtiss JN 4 with a 150 H. P. engine should be sufficiently speedy to make the border safe for white people, and the wireless system as used on the planes of the R. F. C. would be sufficient to enable the scouts to keep scattered ground stations informed as to conditions on the other side of the border. Troops with truck transportation could then be rushed to any needed point quickly. The same factors would enter into the detection of bands of smugglers of sheep, cattle and horses.

When I reported back from Reserve to the C. O. of my Infantry outfit at Dallas in August, my border experience immediately became useful. I was used as instructor on everything from the school of the soldier to guard duty, and was especially useful at two-arm semaphore and wig wag instruction. In September, we were moved to Camp Bowie. Until the latter part of December, I continued on the same general lines of work, managing to grab a ride in one of the JN 4s occasionally, and to keep pretty well up on wireless and aviation, which, with photography, are my hobbies. Just as my papers for examination as a cadet in the Aviation Section were completed, I was transferred to the Mobile Ordnance Repair Shop, for duty with the 111th Ammunition Train; here I acted as Supply Sergeant for a time, being relieved so I might get a chance at some of the mechanical work in the repair shop of the QMC, where our men have been working. I appeared before the Aeronautical Board O. K., but just as I was about to be called up for the physical exam, word came from Washington to discontinue all exams until further notice. That finished it, so I put in my application for a transfer to the Aviation Section as an enlisted man, with the hope that the good that I could do there while waiting for the rest of my exam would be more than I would be doing here in the shop and on the field. I am waiting for results on that now, and in case it is favorable, I expect to be assigned for duty.

However, The Wireless Age readers are more concerned with how the Signal Corps is progressing than with my personal affairs. So I'll try and tell something of the training. A few days ago the 111th Field Signal Battalion had a field meet. Major George Robinson is in command of the Bn. and he sure is developing a first class organization; they are full of pep and the meet showed that they are all taking the greatest interest in everything they go into. It took Company B about 45 minutes to set a pole, climb it, bore a hole, come down, take up the cross arm, fasten it, and get back to the earth. In opening station, establishing communication and closing station, with a distance of 300 yards to cover, a section of the wire company completed the cycle of operations in 7 min. 55 sec. Nice work, eh?

In the wireless company contest for opening and closing stations, field pack sets were opened in 150 yards, a message sent, the set taken down and closed, in about 5½ minutes, the time for setting up being 2 mins. 35 secs., and taking down 2 mins. 20 secs. Some speed, I'll say.

In the telephone station contest, one section succeeded in opening station, running 8 lines, and connecting on the other end in 100 yards in 28 seconds. In the receiving contest, Sergeant White of the outpost company took 49 words per minute for first.

Gas mask donning was an interesting stunt, inasmuch as one soldier got his on and adjusted in 5 seconds; 6 seconds is the requirement, and probably is the average. It took one signal man 1 1-3 minutes to run 100 yards, get his saddle, return and saddle up. The boys, by the way are working on horsemanship, as well as motor vehicle work.

In the motorcycle races, riding solo, there were spills galore, as the course was dished the wrong way, allowing a man to spill outwards instead of riding the saucer. One officer seemed to slide over on every circuit, but he was game and finished. The time was just over 10 minutes for 5 miles for enlisted men, and a little more for officers. In addition to these stunts, there were sack races, litter drill, mule races, tent pitching, first aid, blindfolded school of the squad, biscuit eating, cigar lighting race, wheel barrow race, broad and high jumps, dashes and tug of war; and for a wind up—a singing contest for quartettes! If that wasn't a strenuous day, it wasn't a thing.

We are close enough here to the flying fields to see all their manoeuvers, and scores of R. F. C. and American planes fly over camp every day, sometimes solo and sometimes in formation. Stunts are pulled only on occasions, but we do see some of them. The air apparently gets "bumpy" here during hot weather, as I have noticed that they do not fly as low as they did during the cold weather, and when one does come close down, he is not as steady as in the winter. We are close enough to the panhandle to get cold nights and far enough south to get hot days, and I can imagine scores of flocks of mosquitos coming up from the Trinity bottoms when it gets hotter, too.

I get the magazine all right, but a little late. As long as I get it, though, I'll not kick, as there is so much to study in it that I never get through with one in time to start right into the other. If a fellow will study all that comes in The Wireless Age, he will be a shark on all of the kindred sciences, I'll say. I find that my knowledge of wireless (for which The Wireless Age is responsible) was quite an aid in passing the mental exam for the Aviation Section. Here's hoping that I will go through the physical as well.

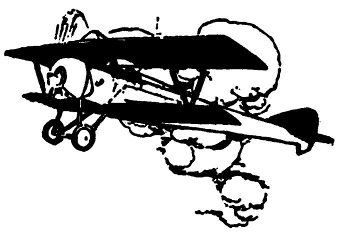
Regards to all my Wireless Age friends, and let the good work go on. The magazine's work for preparedness will help a lot more before the war is ended.

(C) Comm. Pub. Info.

The terrors of war are being realistically simulated at Camp Kearney, Cal., in the training of our soldiers. Nothing is left undone to make the conditions similar to those which the men will have to endure on the European front. The picture shows a gas attack during a midnight maneuver

How to Become an Aviator

The Twelfth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By Henry Woodhouse
Author of "Text Book of Naval Aeronautics."

FUNDAMENTALS of aviation engine theory of operation and construction of parts may now be said to have been covered in the articles of this series. It but remains to consider as types, a few of the more advanced engines, and the balance of motor instruction for the student aviator left to shop practice where actual assembly should be undertaken. The engineering factors which enter in the design of motors can be made a supplementary study, if desired, but the air pilot of wartime is not required to have the full mathematical knowledge of the laboratory expert, acquired only by painstaking study and entire concentration on that particular phase of aviation.

Due to the ever-changing refinements of design the aim has been to present the various parts as representative of the best practice, describing the function and operation and, in a brief manner, the construction. In this way the aviator learns the fundamentals, so that he is able to instantly comprehend the operation of any advanced design which he may later encounter.

A word may be said on bore and stroke ratio. While nothing fixed, definite and exact may be stated on the proper proportion of bore to stroke, it is clear that an engine with a short stroke will run at high speed smoothly but is of poor efficiency at low speeds. When the stroke is much longer than the diameter of the cylinder bore, the reverse is true. A bore of 5 inches and a stroke of 8 inches is considered a long stroke ratio, 4" x 5" a short stroke. Since both ratios have their disadvantages there is no agreement of opinion among designers; thus in seven representative types of aviation motors the following ratios are found: 4x5, 4x5½, 4x6, 4¼x5, 4⅝x5, 5x6½, 5x7. Among foreign motors the average is a stroke 1.2 times the bore dimension. The general trend in motor design is steadily leaning toward the short stroke, or high speed engine, and recent calculations make it appear that the practice of restraining piston speed to 1,000 feet per minute will be abandoned.

A few representative types of multi-cylinder engines will now be briefly considered.

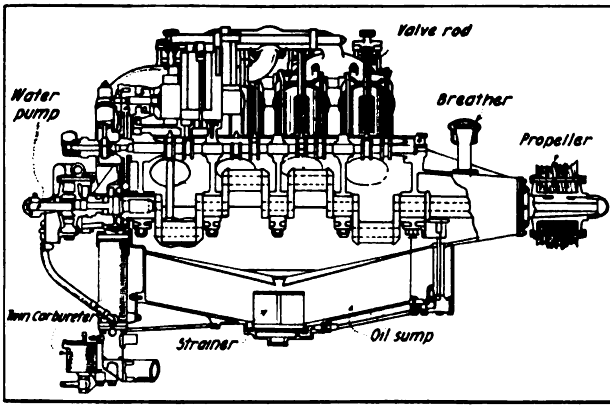


Figure 67a—Part section view of 8-cylinder V-motor

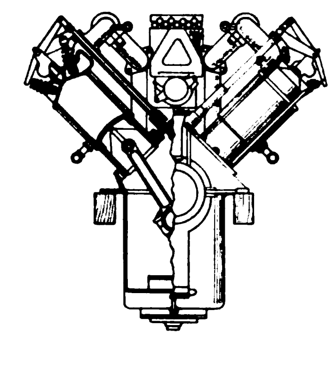


Figure 67b—Part section view of same motor from the front

V-TYPE MOTORS

The salient advantages of increasing the number of cylinders in aviation engines are, briefly, high speed with decreased vibration, flexibility and quick operation, overlapping power strokes and lighter reciprocating parts. The addition of more cylinders to the vertical type of motor is impracticable because this would require a length too great for the fuselage and a much stronger and heavier crankshaft; the best solution is therefore found in two sets of cylinders inclined inward at an angle, thus producing a motor of same length but increased power, or the V-type motor.

8-CYLINDER V-MOTOR

The standard Curtiss engine is shown in part section in figures 67a and 67b. It will be noticed that the length of the motor and crankshaft is practically the same as in a 4-cylinder engine, and the additions are merely another set of cylinders and connecting rods.

In this engine the cylinders are set at an angle of 90 degrees, or one-half the firing distance of the 4-cylinder engine. That is, in this V-type motor the power impulses occur every 90 degrees instead of 180 degrees. In the Curtiss OX, or 90 horsepower engine widely used in training machines, the cylinders have 4-inch bore and 5-inch stroke, is normally run at 1400 revolutions per minute (r. p. m.) and weighs 390 pounds complete.

The main difference between the 8 cylinder V-motor and the 4-cylinder vertical, is the arrangement of the connecting rod; it is common practice to have two rods attached to the same crank throw. This is accomplished, (a) by staggering the cylinders and having the connecting rods attached side by side to the same crankpin, or (b) the lower end of the connecting rod is forked just above the crankshaft bearing, and the rod from the cylinder opposite connected to the crankshaft bushing (at a right angle) between the fork.

The firing order is generally the same as in a 4-cylinder motor, except that the explosions occur alternately in each set of cylinders.

12-CYLINDER V-MOTOR

The development of the multi-cylinder engine to 12 cylinders responded to the demand for more power. In V form, it possesses the same advantages of arrangement and lightness of weight of the 8-cylinder, and obviously reduces vibration still further. That is, where the 8-cylinder engine has four power impulses per revolution, the 12-cylinder motor gives six explosions per revolution.

The usual practice has been to set the cylinders at 60 degree angle, but the latest design favors an angle of 45 degrees.

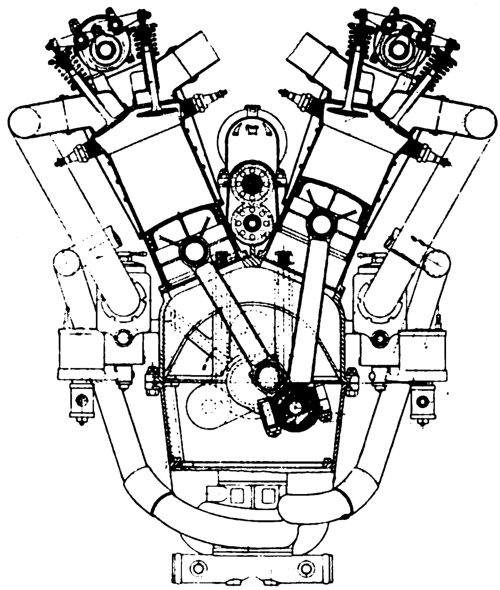


Figure 68—Cross section Renault twelve-cylinder engine, illustrating many features of advanced design

THE LIBERTY MOTOR

Details of the general construction of the Liberty motor have been given in an authorized statement issued by the War Department, extracts from which follow:

CYLINDERS

The cylinders follow the practice used in the German Mercedes, English Rolls Royce, French Lorraine Dietrich and Italian Isotta Fraschini. The cylinders are made of steel inner shells, surrounded by pressed steel water jackets. (This construction is clearly shown in figure 68, a cross section of a Renault engine). The valve cages are drop-forged welded into the cylinder head. The principal departure from European practice is in the location of the holding down flange, which is several inches above the mouth of the cylinder.

CAMSHAFT AND VALVE MECHANISM

The design of the cam and valve mechanism is based on the Mercedes, but improved for automatic lubrication without wasting oil. Figure 68 illustrates a good example of the type, which has been described in detail on page 666, May issue. The camshaft drive is of the Hall-Scott type.

ANGLE BETWEEN CYLINDERS

The included angle between cylinders of the Liberty motor is forty-five degrees, or similar to the illustration, figure 68.

The general practice in 12-cylinder engines has been to set the cylinders at sixty degrees, but by lessening the angle each row of cylinders is brought nearer the vertical and closer together, saving width and head resistance, reducing vibration and giving greater strength to the crankcase.

IGNITION

A specially designed Delco ignition system is used.

PISTONS AND CONNECTING RODS

Hall-Scott design has been followed for Liberty motor pistons; these are similar in type to those shown in the drawing above. The connecting rods are of the straddle or forked type, the fork being just above the bearing at the crankshaft end.

CRANKSHAFT AND CRANKCASE

Standard 12-cylinder engine practice is followed, except as to modifications in the oiling system.

LUBRICATION

The first system of lubrication followed the German practice of using one pump to keep the crank case empty, delivering into an outside reservoir, and another pump to force oil under pressure to the main crankshaft bearings. This lubrication system also followed the German practice in allowing the overflow in the main bearings to travel out the face of the crank cheeks to a scupper, which collected this excess for crankpin lubrication. This is very economical in the use of oil and is still the standard German practice.

The present system is similar to the first practice, except that the oil, while under pressure, is not only fed to main bearings, but through holes inside of crank cheeks to crank pins, instead of feeding these crank pins through scuppers. The difference between the two oiling systems consists of carrying oil for the crank pins through a hole inside the crank cheek, instead of up the outside face of the crank cheek.

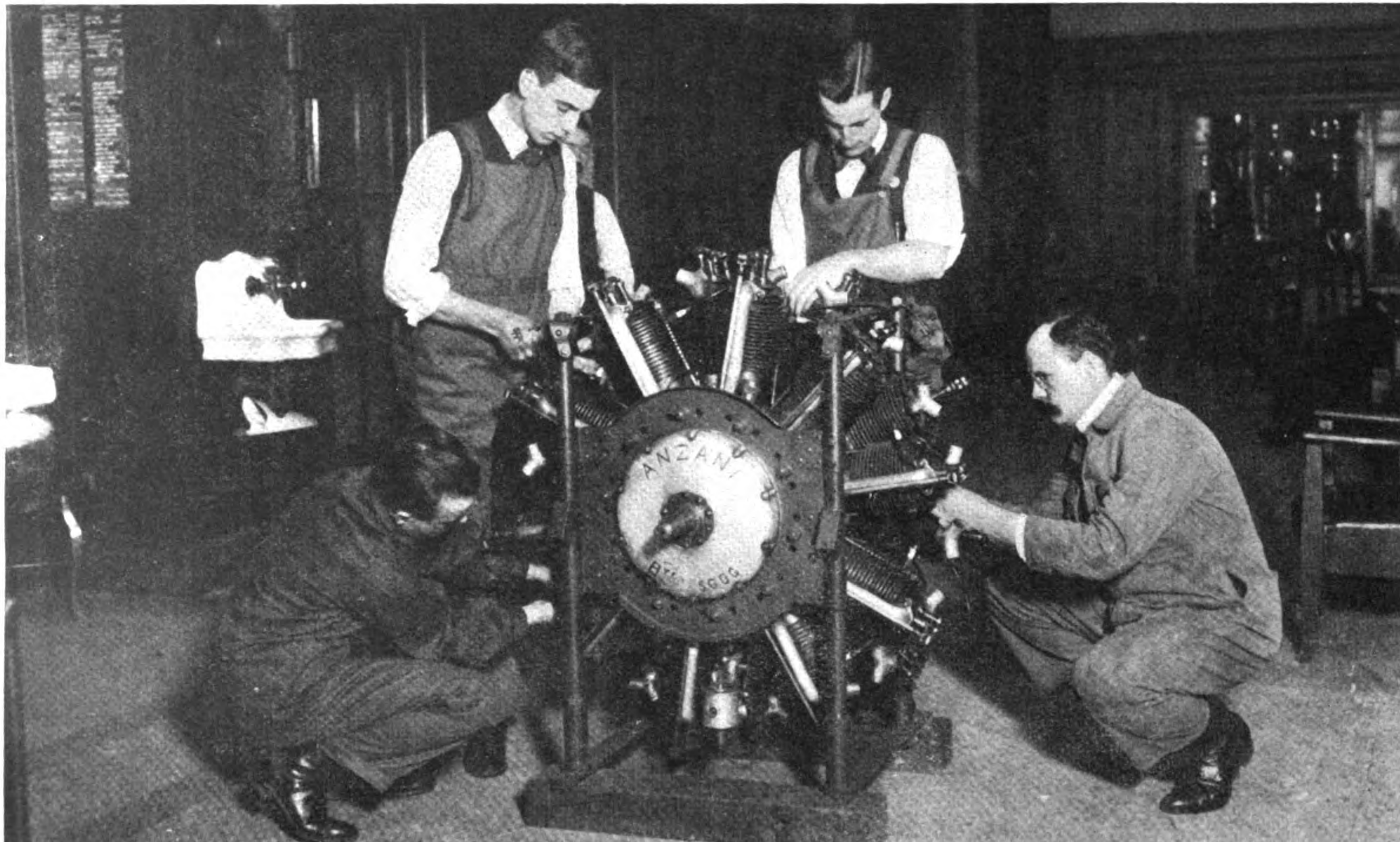
CARBURETOR

The carburetor is a Zenith development. The compound nozzle principle of the Zenith and the constructional details were described in the May issue on pages 668 and 669.

BORE AND STROKE

The bore and stroke of the Liberty engine is 5x7 inches.

The first Liberty motor was an eight-cylinder model, delivered to the Bureau of Standards July 3, 1917. The eight-cylinder model, however, was never put into production, as advices from France indicated that demands for increased power would make the eight-cylinder model obsolete before it could be produced.



(C) Int. Film Svce.

A 20-cylinder Anzani motor, built for transatlantic flight, under examination by Y. M. C. A. student mechanics

Figure 69a—General view of nine-cylinder rotary engine

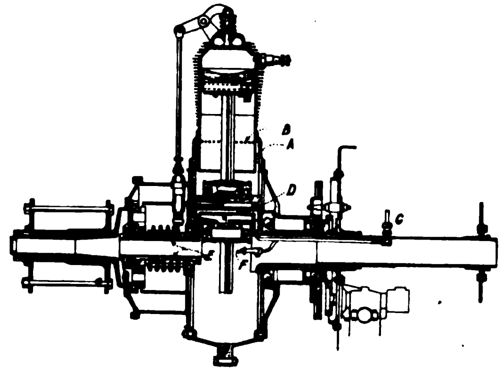


Figure 69b—Section view of rotary engine cylinder and crankcase

ROTARY ENGINES

The principal claim advocated for the rotary motors is that the design makes for light weight. It has been observed, however, that the rotating feature has little to do with this advantage, for the weight would not be perceptibly increased if the cylinders were stationary and the crankshaft revolved. Setting cylinders radially from a crankcase of a size not much larger than that which one cylinder would require is an obvious weight saving. The absence of reciprocating parts aids smooth running and the full practicability of air cooling is an added advantage. The head resistance is a disadvantage, and the loss of power (estimated at 7 per cent.) in driving the cylinders around the shaft, and the difficulty of securing high compression, further handicap this design.

GNOME ENGINE

The figures 69a and 69b show the famous Gnome engine with nine radial cylinders. The explosions occur in each alternate cylinder as the engine revolves, the odd number thus securing a uniform period of explosion. The cylinders, the construction of which is shown in section in figure 69b, are machined from solid 6-inch steel bars, 11 inches in length, weighing less than 100 pounds.

The operation of the engine is as follows:

Vaporized gasoline is forced into the crankcase through the jet F (figure 69b) entering the cylinder through the holes A, B, when the piston is at the lowest point. As the piston ascends it covers the port and the gas is compressed and fired in the usual manner. The large valve in the cylinder head is the exhaust, operated by a cam and rod. Lubricating oil enters at C on the stationary crankshaft, passing to the stationary crankpin D and flooding the bearings E. A portion of the oil which lubricates the crankpins is thrown by centrifugal force through the connecting rod tubes and in the same way oils the piston pins and cylinders. Additional lubrication of the cylinders is secured by oil which is thrown through crankcase holes.

In figure 69a the engine is shown with the crankcase cover removed, revealing the cams and gears. One of the nine holes in the crankpin, through which oil is fed to the nine cams, is indicated at A. The cam rollers, one of which is shown at B, carry oil over the surface of the cam, surplus oil feeding through the guides (C) of the valve rods, through the ball joint D and hollow rod E to the pin F. A groove on the valve lever carries the lubrication to the lever bearing G.

Other aviation engines of the rotary type include the Anzani, Le Rhone and Clerget, constructed with varying number of cylinders up to fourteen.

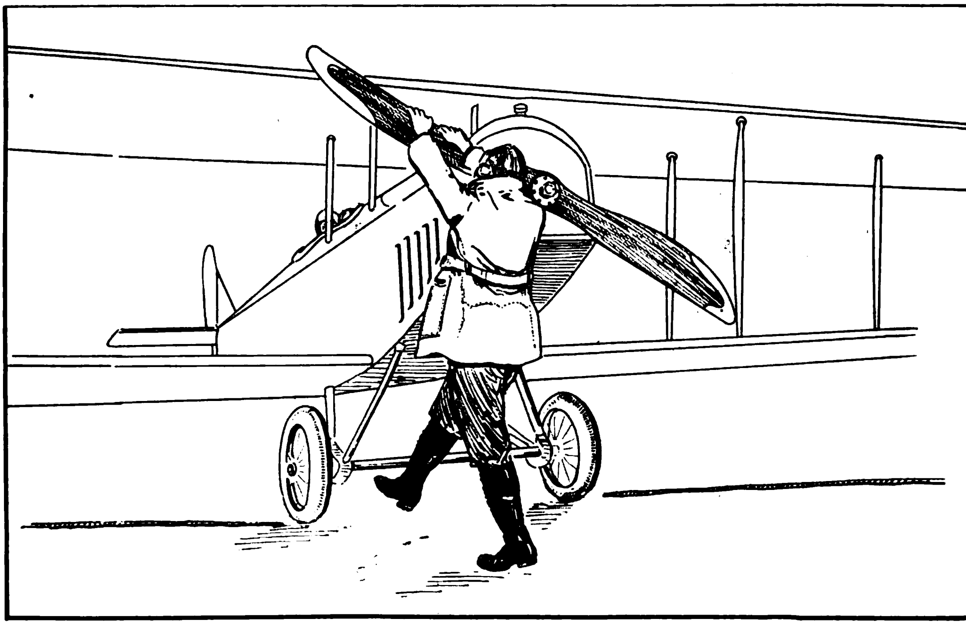


Figure 70—The proper method of swinging the propeller

STARTING THE ENGINE

PREPARATORY

The ground selected should be firm so that the foot will not slip when the propeller is swung. The blocks are then placed in front of the wheels with the cords laid toward the wing tips. A mechanician takes his place at each wing tip, grasping the bottom of the outer strut to steady the airplane when the engine is running; they pull the blocks away when the pilot signals he is ready to start. Two or more mechanicians take their places at the tail end of the fuselage to hold it down while the engine is running.

SWITCH OFF

The ignition switch must be in the "off" position before any attempt is made to swing the propeller. Many fatal accidents have resulted from carelessness on this point.

With engines of the rotary type it is often necessary to prime the cylinders by squirting gasoline through each exhaust valve. Two things are to be remembered in this connection: The squirt can must be clean and the ignition switch off.

GASOLINE ON AND AIR CLOSED

The pilot ascertains that the gasoline is on and the air intake almost closed, so the mixture may be rich for the first few explosions.

ROTATION OF PROPELLER

The propeller is swung with the ignition switch off to fill the cylinders with gas.

CONTACT

The mechanician calls "contact" at this juncture, whereupon the pilot throws the ignition switch on, and replies "contact."

SWINGING PROPELLER

The propeller is grasped as shown in figure 70. Note particularly the position of the feet. One good downward swing of the propeller is made and the mechanician immediately stands clear. If the engine fails to start the mechanician calls for "switch off" and repeats the same operation.

Once the propeller has been given its downward swing, the mechanician must stand clear immediately, as the possibility of a backfire from the engine is great and the backward swing of the propeller may result in a fatal accident. The illustration, figure 70, should be carefully studied, with particular reference to keeping the feet apart and in a position where the body will naturally swing away with the downward pull.

SIGNALS

The following procedure is standard with the Royal Flying Corps.

1. The pilot ascertains from the rigger and the mechanician that everything is correct, immediately after entering the machine.
2. Mechanician—"Switch off?"
3. Pilot—"Switch off."
4. Mechanician—"Gas on—air closed?"
5. Pilot—"Gas on—air closed."
6. The mechanician rotates the propeller to fill the cylinders with gas.
7. Mechanician—"Contact?"
8. Pilot—"Contact."
9. The mechanician swings the propeller and stands clear. The engine runs for a few minutes until the pilot is assured that the motor is in good working order.
10. Pilot waves hand from side to side.
11. Mechanicians pull blocks away from wheels.
12. Pilot looks at aviation mechanician or senior non-com, who ascertains if all is clear ahead and above for the ascent. He indicates all clear by saluting.
13. Pilot waves hand in fore and aft direction. This is the signal to start and all stand clear instantly, the mechanicians at the tail letting go immediately.

SELF STARTERS

There are two methods of cranking aviation engines by starting systems employing compressed air. One turns the crankshaft by means of an air motor and the other admits compressed air to the cylinders, forcing the piston down by pressure and thus turning the motor over. In the latter case, air for the system is supplied to a reservoir by an air pump driven by the engine and, when needed, enters the top of the cylinders in their proper firing order by means of check valves which open inward only and close by explosive pressure once the engine is running.

Developments of the electric starters familiar to all automobilists are also being employed on aviation engines. These are of the storage battery type with the current generated by the engine when running and stored for use until needed. The motor in this instance is turned over when electrical communication is made between the storage battery and the motor-generator unit, which then acts as a motor and turns the engine over by means of gearing to the crankshaft.

FUEL CONSERVATION IN FLIGHT

A final word may well be added before turning to the aspects of actual flight. When flying, the pilot must bear in mind that the maximum speed of the plane is not its most efficient flight speed, and driving the machine at full power must not become an habitual practice. The aviator soon learns by experience the range of speed of his machine and upon this knowledge must base his calculations for long flights, so his fuel may be properly conserved for the task in hand.

To illustrate, a given motor may be assumed to develop 90 H.P. at 1300 r.p.m. and consume 1-10 gal. of gasoline per horsepower hour, or 9 gallons per hour. If the gasoline tank holds 18 gallons and the speed at 1300 r.p.m. is 80 miles per hour, the duration of flight will be 2 hours, or 160 miles. If then, the number of revolutions is reduced to a point where the fuel consumption is one-half (at a speed, say, of 60 m.p.h.) the fuel will last twice as long, or 4 hours, and the distance covered will be

60 m.p.h. x 4 hrs. = 240 miles

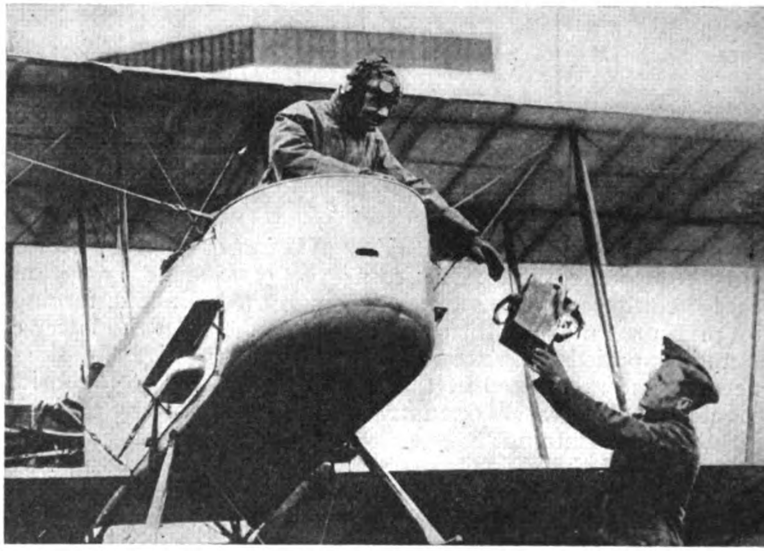
as against 160 miles at the greater speed.

When flying at high altitudes, 10,000 feet or more, motor troubles increase. The explosive mixture changes in character, due to the decreased density of the air supplied to the carburetor. Lessened supply of air results in increased richness of mixture and, disregarding factors of motor design and construction, the amount of power obtained will vary with the changes in the proportions of the gasoline vapor. Increased air in the mixture means fuel economy, but lessened power. With a rich mixture, on the other hand, though the power curve rises, the motor and its parts overheat, delicate adjustments are thrown out and carbon deposits appear in the cylinders. The adjustment of the gas mixture is therefore of importance, the normal ratio for aviation engines being one part of gasoline to 9 to 18 parts of air.

In the thirteenth article of this series, which will appear in the August issue, the principles of general and cross-country flying will be discussed.

How the Eyes of the

Photos: British

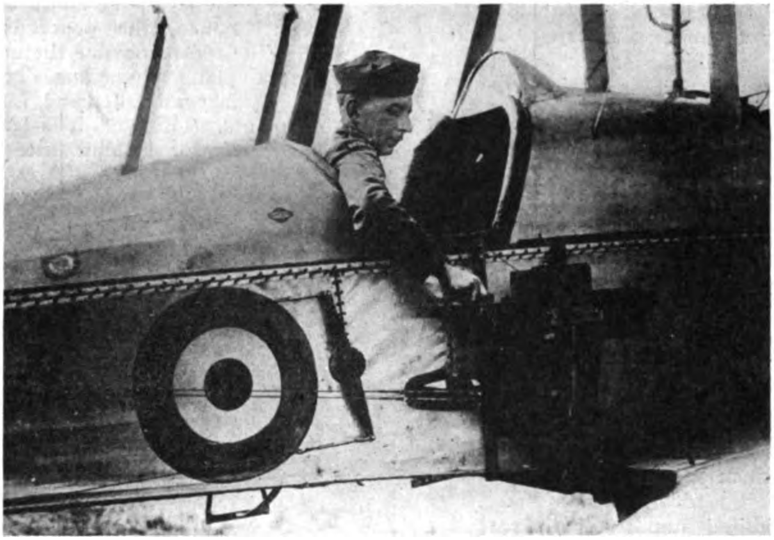


The airplane observer is here shown in the nacelle of a pusher machine receiving his camera, preparatory to starting over the enemy lines on an observation trip

The messenger mounted on a motor cycle receives the exposed plates the minute the aviator reaches the ground and speeds with them to a dark-room mounted on a truck where they are developed

Army Record Observations

Official



The method of taking observation photographs is shown in this view of the aviator snapping the shutter of the camera fastened to the side of a tractor airplane

This view shows how the snapshots are assembled to make an accurate map of the enemy territory for staff use. The assembler uses as a guide a military outline map

Aviation News

Board to Grant Air Licenses

The board which will grant civilian licenses to operate aircraft has been announced. It includes Major-Gen. George O. Squier, chief signal officer of the army, as chairman. The other members are Col. H. H. Arnold, Signal Corps; Lieut.-Col. Claude E. Brigham, Coast Artillery; and Capt. Noble E. Irwin, Capt. T. R. Y. Blakeley and Capt. F. H. Clarke to represent the navy.

All aviators except officers of the army and navy, must obtain licenses from this board for the operation of balloons, seaplanes or aeroplanes.

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Signal Corps Requires Draftsmen

In a statement authorized by the Civil Service Commission, the following appears: "The Signal Corps of the Army is short of aeronautical mechanical draftsmen. The Navy has an unlimited number of places for draftsmen of various kinds and for a long list of technical workers."

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Major Thaw An "Ace"

Major William Thaw, commanding the Lafayette Flying Corps, is now counted among the "aces" in aviation in France, having brought down his fifth adversary and a captive balloon on the same day, April 20.

Major Thaw within a month has accounted for three opponents in aerial encounters.

A dispatch from Paris relating to the exploits of American aviators says:

"On April 20 Major Thaw, commander of the Lafayette Squadron won a splendid double victory, bringing down in turn a Drachen and a monoplane. These two victories permit him to be enrolled among the prize aviators.

"Since he assumed the command of the glorious unit, he seems to have particularly distinguished himself. Major Thaw evidently wishes to set an example, and many of his compatriots will take their places within a short time among the air champions."

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Speaking at the Royal Institution, Professor Pope stated that air photography for military purposes is now being done with the aid of plates sensitive to the several colors of the spectrum.

Gas Used for Testing Aero Motors

Recently the Detroit City Gas Co., an American Light and Traction Co. subsidiary, sold some $1,250,000 bonds, the proceeds to be used to finance the additional plant extensions due to the increased demand for gas in munition plants. This gas, it is learned, is being substituted for gasoline in testing airplane motors. So comprehensive is the aero motor building business that this new use for gas in Detroit has increased the daily demand 5,000,000 cubic feet.

Postmaster Patten starting Lieut. Webb on first airplane mail trip, from New York to Washington

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Red, White and Blue Circles on U. S. Machines

Red, white and blue circles and stripes will be the distinguishing mark of Uncle Sam's army and navy airplanes, the Signal Corps announced.

The wings of the planes will be marked with a red bullseye. The rudders will be marked with vertical red, white and blue stripes.

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The War Department has made a new ruling that civilian instructors will no longer be used in aviation schools and only commanding officers will do the instructing.

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

By Major J. Andrew White
Chief Signal Officer, American Guard

FOURTEENTH ARTICLE

The Wire Company—II

FORMATION OF THE COMPANY

The habitual formations are: *The order in section column, the order in line,* and *the order in platoon column.*

The order in section column is that in which the sections of the company follow each other in the order, or the reverse order, of their numbers, from front to rear. The distance between the mounted men and carts in a section, between sections and between platoons is 2 yards.

The order in line is that in which the sections of the company are formed abreast of each other in the order, or the reverse order, of their numbers from right to left. The interval between the sections and between platoons is that which would result from the sections moving from the order in section column by the flank.

The order in platoon column is that in which the platoons of the company, each in the order in line, follow each other in the order, or the reverse order, of their numbers from front to rear. The distance between the platoons is that which would result from wheeling the platoons from the order in line to the order in platoon column.

Employment in the Field

GENERAL

The main equipment of each of the four wire sections is a two-horse reel cart carrying 5 miles of Signal Corps field wire and the buzzers and other apparatus for establishing the necessary stations. Wire can be laid out and recovered at fast gaits and stations established or discontinued in a few seconds.

Buzzer wire carriers, each with a quarter mile of buzzer wire, can be

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

used in emergency or where it is impracticable to lay the field wire. Each section carries 1½ miles of buzzer wire and 4 buzzer wire carriers.

Whenever practicable, a reserve of equipment will be kept on hand to provide for a sudden move of the headquarters or other station. For this reason the company commander must take up every opportunity to reel up wire no longer used. This can often be done as the action progresses or after a move of headquarters.

When a wire line is discontinued, every effort will be made to recover the wire, and wire or matériel will not be abandoned unless its recovery has become impracticable.

When lines are laid within the zone of fire or observation of the enemy, the men laying the lines will take advantage of cover to conceal their position and movements. Sections should not be placed in positions exposed to the enemy, nor, on the other hand, in places where it will be difficult for those for whose use the line is established to find them readily.

On the March

The position of the wire company in the column is not important unless resistance is expected. In the latter case, the company should be where sections and platoons may proceed promptly from division headquarters and lay lines to the brigades and other units as soon as they deploy. To be in a position to meet this requirement, the company should be at or near the head of the main body.

In case it is desired for tactical reasons to maintain communication between different parts of a division on the march, this service should be rendered by means of the radio sets rather than by the use of wire lines. The use of the latter on the march is more exhausting to the Signal Corps personnel and uses wire which may be urgently needed for combat lines at any moment when contact with the enemy is possible.

In Battle

When resistance is encountered and the division is deploying opportunity for the most useful and important application of the wire company is presented. The division commander or a representative will indicate by formal field order or otherwise the wire lines it is desired to establish. As soon as possible, the captain designates an initial point for the beginning of wire laying and assigns sections and platoons to suitable tasks.

The strictest economy of wire and other matériel should be observed in planning for and laying the lines to the end that same be not uselessly expended and found exhausted at a critical stage. As large a reserve as possible of wire and equipment should be assembled at a central point with which to effect replacements and meet unexpected demands. It is advantageous and most usual to play wire from a point near division headquarters outward. A principal advantage lies in the fact that the reel cart is thus placed at the end where changes of position are most frequent.

In Camp

When the division goes into bivouac or camp the wire company establishes such tactical lines of information as may be indicated. These will usually be wire lines on the ground and will connect division headquarters with brigades and important outposts and observation points.

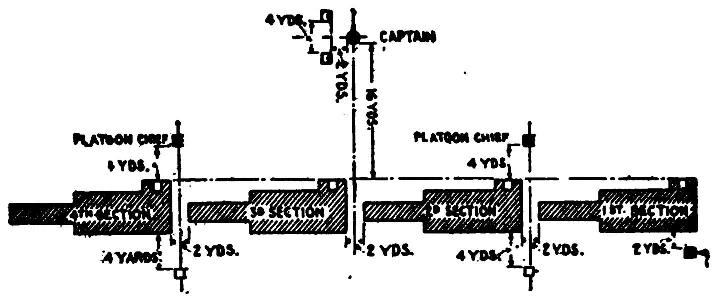
Reserve Wire Carts

The two extra wire carts in the company carry 10 miles of field wire each, which constitutes a reserve supply for issue to subordinate units when necessary. The captain regulates the issue and use of this reserve matériel in the most judicious manner for supplementing and replacing the equipment per-

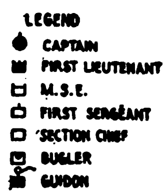
taining to subordinate units. The reserve wire carts and the company instrument wagon constitute a part of the company combat train and should march in rear of the company.

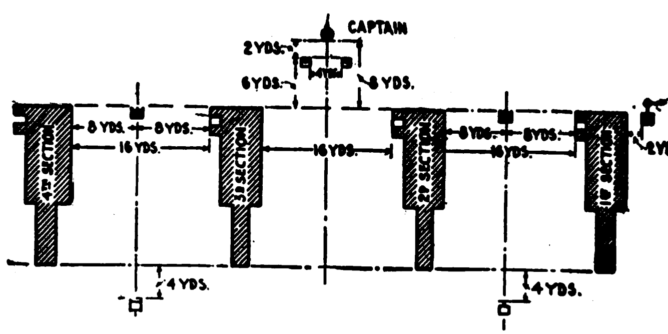
RECONNAISSANCE

A most important preparatory measure for units of a wire company to take before actually laying indicated ground lines of information is to pro-



COMPANY IN COLUMN





COMPANY IN LINE

vide for as complete a reconnaissance as time will permit of the route to be followed in laying the wire. Such reconnaissance will be accomplished by suitable reconnoitering or scouting parties detailed from the personnel of the sections or by such detachments of the company staff as the captain may direct.

These scouting parties will examine carefully the general route to be followed in laying the wire with a view to selecting the particular route (a) which best utilizes the existing matériel and artificial cover along the route; (b) which offers the least difficult terrain to traverse; and (c) due regard being had for the above, that route which is the shortest and which involves the laying of the least possible amount of wire.

It is incumbent on the scouting party in front to *mark the route* so that uncertainty may not arise as to the direction to be followed. A marker is made to understand clearly:

(a) The route to be followed.
(b) The particular unit or units to be guided.
(c) The message, if any, to be delivered.
(d) Other directions to be carried out or the route he is to follow in order to rejoin his party.

The marker indicates the correct route, acting as guide if necessary over terrain where the route is difficult to follow, and as soon as his mission is fulfilled hastens to replace the next marker or to rejoin his detachment or detail.

By the establishment of well-understood conventions, or by the use of suitable signs, the number of markers may be reduced. Thus, it should be understood that a main traveled road is not, without indication, to be left for one that is noticeably less traveled, and that a straight road is not, without indication, to be left for one which deviates from it. By marking arrows on trees and buildings, or by other suitable signs, uncertainties of a minor nature may be removed. In important cases, however, a marker should always be left at places where a reasonable doubt may arise.

When the head of the column for which the route is being marked comes within view of a marker the latter *signals* the former, and the former acknowledges with a *countersignal.* Both signal and countersignal should be distinctive and should have been previously agreed upon. The same signal and countersignal are used throughout the detail.

The men designated for the foregoing are selected for special aptitude from the personnel of the sections and the company staff and are carefully instructed in the duties they are to perform.

It will be found advantageous to have those men of a section designated for scout duty grouped in the station squad which is last to establish its station.

Additional men are designated from time to time to receive the instruction so that substitutes may be available. Alert, cool-headed, and intelligent men should be selected for this duty; they should be good horsemen and have good eyesight and hearing.

Each scout should be provided with a good field glass, a compass, a watch, a whistle, a field message book, and a pencil.

The training of a scout should have for its object:

1. To develop his powers of observation.
2. To teach him what to look for and how to recognize it.
3. To teach him how to report intelligently and concisely.

The scout's powers of observation and description are developed first of all by simple exercises. Thus he may be required to look at a given section of terrain and describe what he sees in it.

The scout is made to appreciate the lay of the land as indicated primarily by its drainage, and secondarily by other natural features, and by the works of man. A good eye for country is thus to be acquired; the scout learns to appreciate the configuration of a terrain which may be only partially visible to him, and thus to deduce the most favorable routes for traversing it and the most probable positions for hostile occupation.

The scout must also be taught to distinguish troops of the different arms, to recognize their formations, and to familiarize himself with their usual methods of action.

The scout must be trained (a) to use field glasses; (b) to read maps; (c) to make reports, both verbal and written; (d) to make route sketches.

Signal Corps News

Radio Sergeants Needed

The country is at present in need of a large number of radio sergeants. To qualify for this rating a man should have a high school education, or equivalent. Men who have recently completed their schooling are specially wanted—those who still have their mathematics fresh in mind, have a keen ear and are eager for active service. Men in the draft age may be inducted into the service and men between the ages of 18 and 21 may be enlisted with the consent of their parents. Address Department of Enlisted Specialists, Coast Artillery School, Fortress Monroe, Va.

Expert News Photographers Needed

A number of high-grade news photographers are urgently needed by the Signal Corps. These men must have expert experience in handling of speed cameras, such as Graflex, Graphic, and also understand speeds of lenses and various makes of cameras and operation of same.

Only those men who can furnish references as to their actual experience as news photographers will receive consideration.

The men selected for this branch of the service will be sent to a school for military training. Upon completion of the training they will be promoted to grades of sergeant, first class, and will be ordered overseas in a short time.

Applicants must be citizens of the United States between the ages of 21 and 31.

All communications should be addressed to Air Division, Training Section, Photographic Branch, Washington, D. C.

250 Telephone Girls Go to France

Besides conforming to the qualifications set by the United States Signal Corps for membership in the telephone unit, which is a part of the United States Army, the operators are now required to pass a psychological examination to determine their motives for wanting to go abroad.

"Out of 7,500 applications for membership in the unit of telephone girls which has been sent to France, 250 have been selected," is the statement of Capt. Wesson, Signal Corps officer in charge of the unit. One hundred women, in the official olive-drab uniform of the Signal Corps, have been sent abroad, and 150 are awaiting orders in this country.

These girls are stationed in groups of 10 in American bases of supplies and points of embarkation, according to Capt. Wesson. They will not be nearer than 23 miles from the front.

New York State sent the greatest number of telephone operators, and California and Massachusetts tied for second place.

An officer of the Signal Corps, who is experienced in the employment of telephone operators, is in charge of the housing and general welfare of the operators in France.

The following appointments, authorized by the Secretary of War and made at the military school of aeronautics designated opposite each name, are approved.

To be second lieutenants, Aviation Section, Signal Reserve Corps:

Walter J. Abels, Camp Dick, Tex.; Allen T. Archer, Harold K. Atkinson, George E. Bell, Edward L. Bloom, Richard O. Burr, and Lawrence D. Coffing, Rockwell Field, Cal.; Eugene F. Dugger, Call Field, Tex.; Carl W. Edwards and George J. Golonsbe, Rockwell Field, Cal.; Samuel C. Harrell, Ellington Field, Tex.; Frank K. Hays, Kelly Field, Tex.; Landon Hilliard, Call Field, Tex.; Gero A. Himebaugh, Rich Field, Tex.; Simeon J. Jeffries, jr., Rockwell Field, Cal.; Swift M. Lowry, Kelly Field, Tex.; William C. Morris and William V. Morgan, Rockwell Field, Cal.; Cornelius S. O'Meara, Kelly Field, Tex.; David I. Stoddard and William C. Talbot, Rockwell Field, Cal.; Roy M. Walker, Kelly Field, Tex.; Sanford M. Warren, Fort Omaha, Nebr.

The following appointments in the Officers' Reserve Corps and National Army have been made in the office of The Adjutant General, on recommendation of General Pershing, American Expeditionary Forces, France, to March 25, 1918:

William M. Barbour, first lieutenant, Aviation Section, Signal Reserve Corps.

Sydney W. Beauclerk, first lieutenant, Aviation Section, Signal Reserve Corps.

Robert C. Bedlinger, first lieutenant, Aviation Section, Signal Reserve Corps.

Alfred E. Bennett, first lieutenant, Aviation Section, Signal Reserve Corps.

Leslie B. Cooper, first lieutenant, Aviation Section, Signal Reserve Corps.

Lester B. Cowgill, first lieutenant, Aviation Section, Signal Reserve Corps.

Edmund A. Donnan, first lieutenant, Aviation Section, Signal Reserve Corps.

Joseph F. Gill, first lieutenant, Aviation Section, Signal Reserve Corps.

British Pictorial Svce.

A signal detachment at headquarters, Kara Tepe, Mesopotamia, with the heliograph and buzzer in active use

High Power Stations

Some Features of the Long Distance Stations of the American Marconi Company

By C. H. Taylor

Engineer, Transoceanic Division, Marconi Wireless Telegraph Co.

(Continued from June WIRELESS AGE*)*

TABLES and curves can be drawn up (see figures 4 and 5) showing the relations between the coupling, the number of oscillations for various wave lengths per unit of time, and the stud velocity. The size of the studs and of the electrodes in the direction of motion can be ascertained from them.

The length of the stud at right angles to the direction of motion of the disc is determined by the current capacity of the circuit with which it is to be used, and the side electrodes are built to conform to the dimensions of the stud. The density of the current per inch of sparking surface on these studs should be kept low. From observations made under operating conditions it would appear that one can go beyond the useful maxima that disc studs will handle.

The inductances forming the secondary coil of the coupler, and the loading for the antenna circuit, are built of wire stranded in a manner similar to that described for the primary coil of the coupler. As this wire must be flexible, and as the current maximum is not so great, the amount of copper in this cable is reduced. The cable comprises a number of 7 strand cables laid around a jute core 2½ inches in diameter. Each of the wires of these 7 strand cables is insulated with a double covering of cotton, and the cables spiral around the jute core. A covering of coarse black braid binds the whole group together. Cable of this type is invariably employed in the antenna circuit between the leading-out insulator and the ground connection.

The type of antenna circuit adopted by the Marconi Company is very familiar. The illustration, figure 6, gives a very fair idea of the general arrangement. Advantage is taken of the directive properties of the inverted L type of antenna both with regard to the adjacent receiving stations, as well as to the distant receiving stations. These antennæ are set with their major axes along the line of the true direction of the distant receiving stations. The general dimensions of the circuit depend upon the wave length to be employed.

As the stations we are dealing with were designed to be operated on damped wave trains, and with tone reception, attention had to be given to the dimensions of these circuits, so that the emitted wave trains might have a low decrement, and so that the most might be made of tuning and selectivity at the distant receiving stations. A compromise had to be effected between the antagonistic claims of low decrement and radiation efficiency. The resistance losses of the various parts of the antenna circuit were brought to as low a value as possible. In order to minimise the losses in the ground portion of this circuit the usual group of earth plates were supplemented by a second group, placed under the antenna near the first row of masts, and wires were carried out from the main group of earth plates under the antenna until they reached beyond the last row of masts. These wires were distributed over the surface of the ground in a manner corresponding with the wires in the antenna. In this way the soil of the ground around the station and under the antenna was not entirely depended upon to carry the currents in this circuit. Wires were also extended from the power house, in the opposite direction to that of the antenna, in order to minimise the losses in this portion of the circuit.

As will be plainly evident, it is easily possible to make the decrement too low for the other constants of the installation. By this we mean that continuous decreasing of the decrement will bring us to a value at which the antenna circuit has just ceased emitting one wave-train when it is called upon to absorb energy for the next wave-train. A further decrease will bring us to the state in which the antenna has not completed one wave-train before the energy for the next is

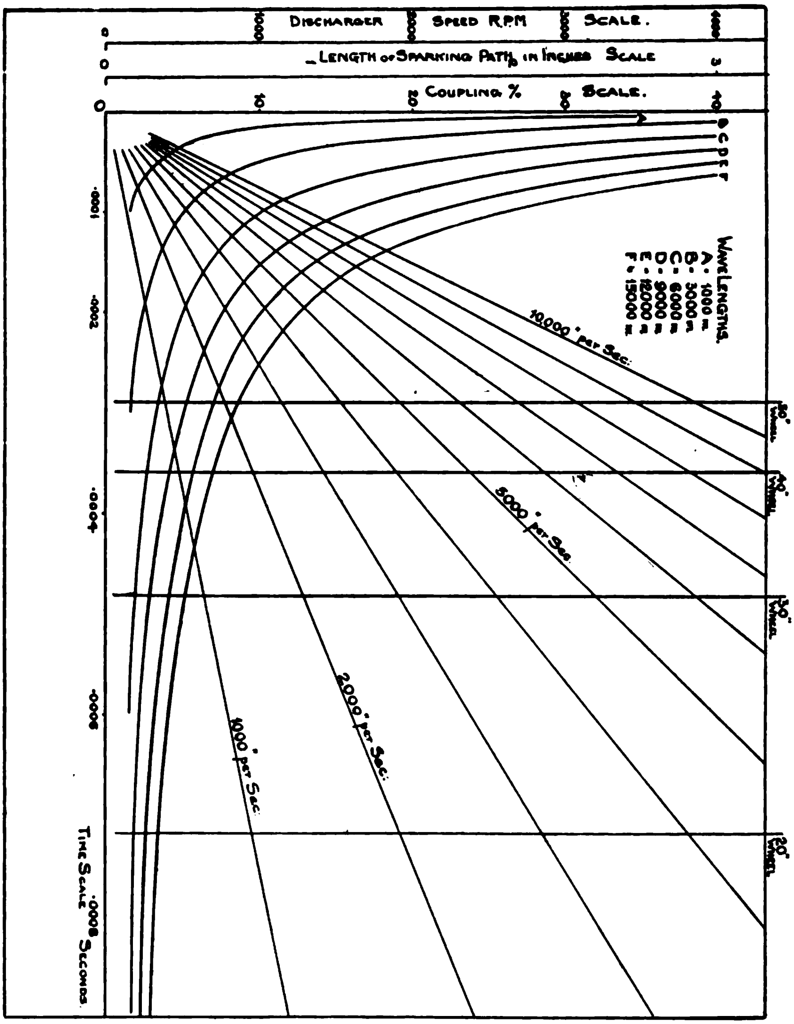


Figure 4—Sparking time, wave-length and coupling

thrust upon it. Such a decrement as this would be too low for a circuit operated as these are, unless there were complete phase harmony between successive wave-trains. As an instance of this we may point to the New Brunswick station. It has a spark frequency of 240, and may be using a wave length of 15,000 meters. Eighty of these oscillations would completely fill the time interval between two successive sparks. Now we must subtract from the complete time interval, the period required to transfer the energy from the primary to the secondary circuit, so that only sixty-eight complete oscillations in the decreasing portion of each wave-train as it left the transmitting station could be allowed. Any lessening of the decrement, that will permit of more than this number of complete oscillations after the antenna is left freely vibrating, will not be of advantage unless the

successive wave trains are in correct phase with each other. On the other hand, any increase in the decrement to give a useful clearance between wave trains might involve a breach of the Government regulations. Even the effect of overlapping wave trains, when they are not in correct phase relation, may give the station an apparent decrement that is higher than the real one for the circuit.

It will thus be seen that, so far as the antenna circuit decrement at the trans-

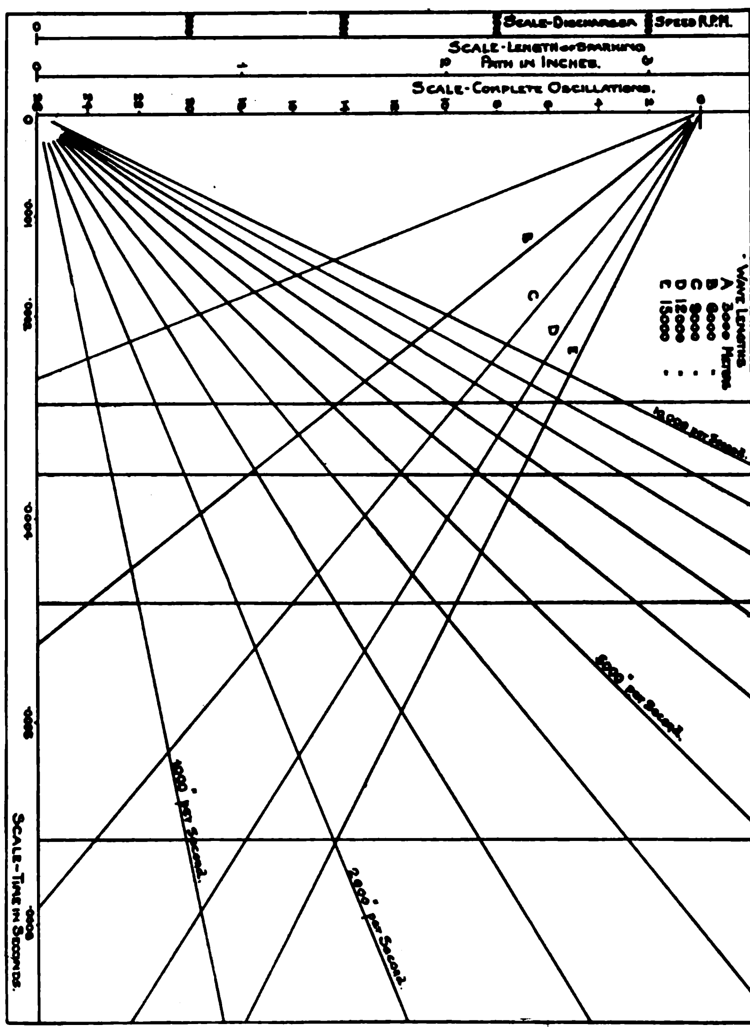


Figure 5—Sparking time, wave-length and complete oscillations

mitting station is concerned, all the demands of the receiving station are not possible of fulfillment. That station would like a very low decrement to the received wave train and a high spark frequency.

In connection with these big antennæ; and in fact, with any antenna that is to be used for continuous commercial work, the atmospheric conditions at and around the station must be taken into consideration in the design. For instance, around New York and north of that city along the Atlantic coast one must expect to experience each winter high winds, snow and sleet storms. Consequently the antenna must be designed to withstand the most adverse of these conditions. Gales can be guarded against without much extra work, but the most severe test is that arising from a combination of snow or ice sleet and wind. If the atmos-

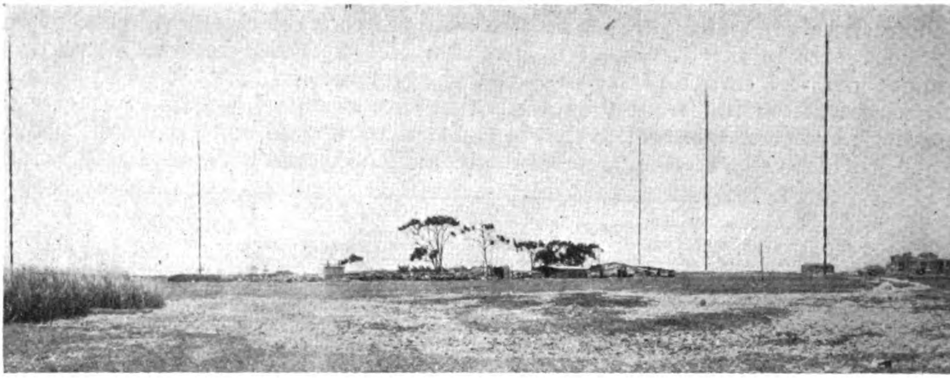


Figure 6—Kahuku receiving station. General view of wireless link between U. S. A. and Japan, in Hawaii

pheric conditions are such as to favour the formation of ice upon the exposed wires of the aerial system; and if, after this has gone on until a cylinder of ice of appreciable diameter has been built around the wires, a wind of moderate velocity starts to blow there will be great danger that some of the antenna wires will break under the increased load. Practical experience has shown that the best method to overcome this trouble is to melt the ice as fast as it is formed. To enable this to be done the antenna wires are grouped together in pairs which run as a loop from the power house to the free end of the antenna and back to the power house, the open ends being at the power house. For normal radio work all these loops end at the power house, and are joined together to a common bus; but in case of necessity they can be cut off from the bus, and each loop (either singly or in groups) can be joined to a suitable 60 cycle circuit, and sufficient current passed through these loops to raise the temperature of each and melt the ice cylinder. At the station in New Jersey an occasion to test out this heating scheme during the early part of 1915 occurred, and it was found that it required 100 amperes per loop to do the work at a reasonable speed. When using this amount of current on wires that were very heavily coated with ice, the effect was apparent within two minutes. The coating of ice had then been melted so that it began to break away, and the loop was quite clear in seven minutes. It is needless to remark that care must be exercised that the current put into the loop is not sufficient to soften and weaken the wire. Treating the antenna wires in this manner interrupts the service for a few minutes, but avoids a possible interruption of some hours.

Another point of interest is the distribution of the current from the foot of the antenna to the grounding system. At these stations the main grounding system comprises two semicircles of metal plates sunk one on the side of the power house nearest to and one on the side opposite to the aerial system. The wires fan out to these plates from the leading out insulators, set in both of these faces of the building, and on that side which is towards the aerial system, the connections to the wires that are laid under the antenna are made over these same wires. Within the power house these two insulators are connected by a copper bus or a length of high frequency cable. At the medial point of this bus the connection to the coupling coil is made, and on either side of this junction a thermal-ammeter is inserted into the bus. In this manner we can see at a glance the values of the current flowing out of the building to each of the two sets of earth plates. These sets of plates are metallically connected together so that the complete ground plate possesses the appearance of a very short cylinder with semicircular ends. It is found that the distribution of the current is not at all equal; the larger proportion flows out on that line that leads directly toward the antenna and the smaller proportion flows out in the opposite direction. This proportion may be as high as 2 to 1 and may vary with the load.

At these long distance stations particular attention has been paid to the receiving end of the circuit. In the early days of commercial radio work the reception was invariably carried out on the same antenna as that used for transmission. This meant that the design of the antenna was treated more with a view to getting good radiation, and the reception had to take care of itself. This was not objectionable so long as very small powers were being used for transmission, but as soon as larger powers were brought into use it was found more expedient to use a separate wire for reception. Although this is an improvement, yet, since the wire is suspended from the same masts as the transmitting wires, the receiving wire is still influenced by the proximity of these other wires, and the response to the incoming signal is not so good as when the receiving wire is suspended from masts with no other antenna connected to them. This pointed the way to a complete separaton of the two functions of these stations, whenever there would be a circuit that had sufficient business to justify the increased expense. At such a station, only considerations affecting the reception of the signals would be entertained, and the antenna would be designed for this separate function.

At these long distance stations this separation has been made, and in consequence each of the two functions of a radio station can be carried on simultaneously—that is to say, the transmitting station can send messages continuously, and the receiving station can receive messages continuously, during the same time over the same circuit.

Advantage was taken of the directive property of the inverted L antenna at these receiving stations. These are located, with respect to the distant and nearby transmitting stations, so that their receptivity was a maximum for the distant station and a minimum for the adjacent one. In order to annul the effect of the adjacent station a compensating antenna is added, also of the inverted L type, and so located that it has its maximum receptivity in the direction of the adjacent station and its minimum in the direction of that of the distant one. By this means the effect of the distant transmitting station can be left unimpaired while that of the adjacent station is reduced to a negligible quantity.

Since the reception is carried on at some point at a distance from the transmitting station, it is found expedient to arrange that the radio operation of the transmitting station be controlled from this same point. This is not a very hard problem. The switch keys that control the condenser circuit are operated through a polarised relay which is inserted in an ordinary land line circuit erected between the two stations. The operator at the receiving station works a land line key, and energises this relay, which, in turn, operates the switch keys and thus controls the radio transmission.

The receiver designed for these stations is of the usual type, with loose coupled circuits built with especial reference to the long waves that were to be employed at these stations. It can be used with both the crystal and the valve detector.

In addition to this, special arrangements permit of the amplification of the incoming signal, so that it could be recorded on a dictagraph cylinder. This record would be made whenever the volume of business necessitated more rapid operation than could be done by hand and ear.

For the operation of this circuit automatically there was installed Wheatstone apparatus with the necessary perforators. Signals sent at a high speed were amplified and recorded on the dictagraph cylinder and transferred from that cylinder by an operator working at a good manual speed. In this manner the circuit could be operated at a speed of from 75 to 100 words per minute.

One advantage that is gained by the separation of the receiving from the transmitting function of these stations is the ability to "break" the operator transmitting. In this there is a great saving of time, and it is found that traffic is moved forward at an appreciably higher rate of speed than when the same stations are not able to work this "break."

It has been found that these independent receiving stations possess very good receptivity, and, in consequence, were rather bothered by the usual atmospheric disturbances and by interference from stations in the vicinity, although these were using much shorter wave-lengths. Some tests were carried out on the comparative receptiveness of wires of shorter length than those proposed

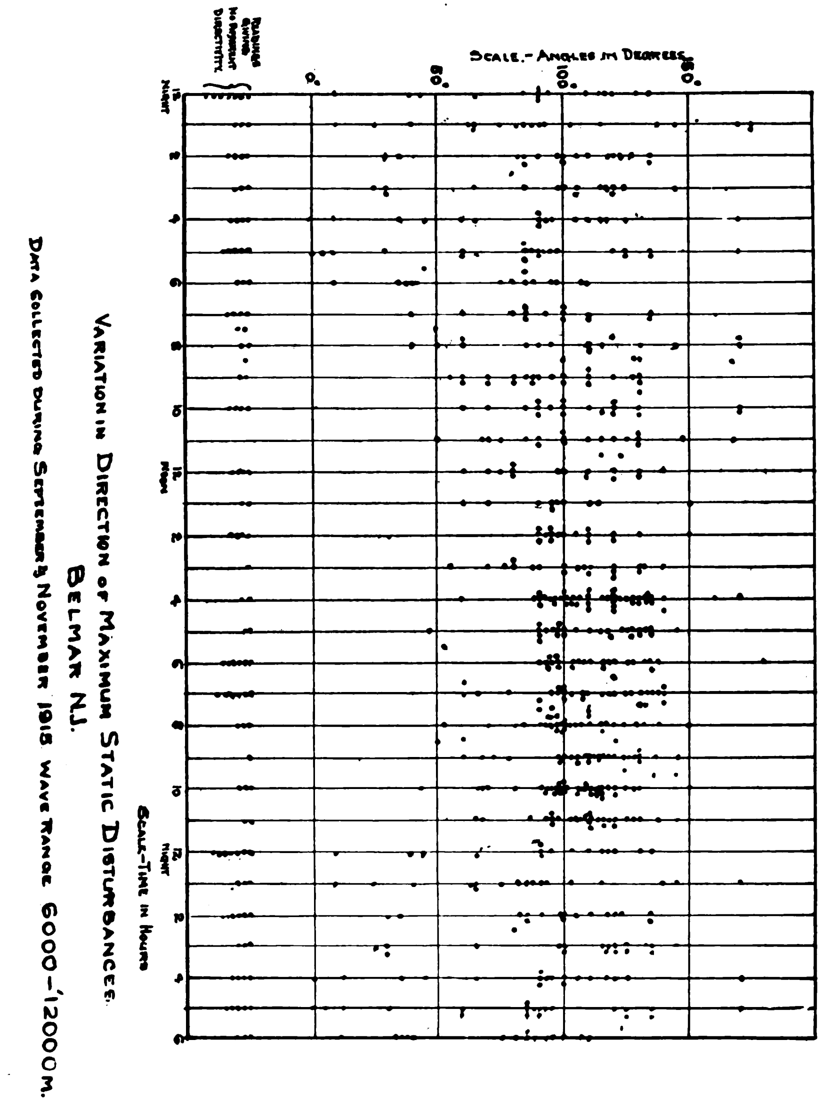


Figure 7—Radio-goniometer tests

for these stations, all wires being suspended at approximately the same height above the earth's surface. It was found that, when shorter wires were used, it was not till the natural of the antenna was increased until it was approximately equal to that of the standard long-wire antenna, did the signals on this antenna attain the same audibility as those on the long wire. Tests were also made on wires suspended from 50 to 30 feet above the ground; these gave signals of less audibility than the standard wire, even when the quantity of wire in each antenna was approximately the same.

(*To be continued.*)

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By Captain Fritz E. Uttmark

CHAPTER VIII.

The Earth, Its Form, Rotation and Dimensions—Mass, Weight and Gravitation—The Earth's Mass and Density

IN a science which deals with the heavenly bodies it might seem at first that the earth has no place; but certain facts relating to it are just such as we have to investigate with respect to her sister planets, are ascertained by astronomical methods, and a knowledge of them is essential as a base of operations. In fact, Astronomy, like charity, "begins at home," and it is impossible to go far in the study of the bodies which aie strictly "heavenly" until one has first acquired some accurate knowledge of the dimensions and motions of the earth itself.

The astronomical facts relating to the earth are broadly these:

1. The earth is a great ball about 7920 miles in diameter.
2. It rotates on its axis once in twenty-four sidereal hours.
3. It is not exactly spherical, but is flattened at the poles, the polar diameter being nearly twenty-seven miles, or about one two hundred and ninety-fifth part, less than the equatorial.
4. It has a mean density between 5.5 and 5.6 as great as that of water, and a mass represented in tons by six with twenty-one ciphers following.
5. It is flying through space in its orbital motion around the sun with a velocity of about eighteen and a half miles a second; i. e., about seventy-five times as swiftly as an ordinary cannon-ball.

It is not necessary to dwell on the ordinary proofs of the earth's globularity. We will simply mention them.

1. It can be circumnavigated.
2. The appearance of vessels coming in from sea indicates that the surface is everywhere convex.
3. The fact that the dip of the sea horizon as seen from a given elevation, is (sensibly) the same in all directions, and at all parts of the earth, shows that the surface is approximately spherical.
4. The fact that as one goes from the equator towards the north the elevation of the pole increases in proportion to the distance from the equator proves the same thing.
5. The outline of the earth's shadow, seen upon the moon during lunar eclipses, is such as only a sphere could cast.

We may add, as to the smoothness and roundness of the earth, that if the earth be represented by an 18-inch globe, the difference between its greatest and least diameters would be only about one-sixteenth of an inch; the highest mountains would project only about one-ninetieth of an inch, and the average elevation of continents and depths of the ocean would be hardly greater on

that scale than the thickness of a film of varnish. Relatively, the earth is really much smoother and rounder than most of the balls in a bowling alley.

There are various ways of determining the diameter of the earth. The best, in fact the only accurate one, is by measuring arcs of meridian, so as to ascertain the number of miles or kilometres in a degree of the earth's circumference.

There are various approximate methods, one of the simplest of which is the following:

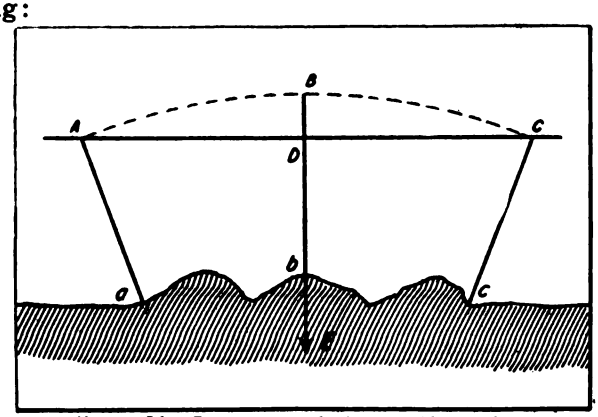


Figure 56—Curvature of the earth's surface

Erect upon a reasonably level plane three rods in line, a mile apart from each other, and cut off their tops at the same level, carefully determined with a surveyor's levelling instrument. It will then be found, on sighting across from A to C (figure 56) that the line after allowing for refraction passes about eight inches below B, the top of the middle rod.

Suppose the circle ABC completed, and that E is the point of the circumference opposite B, so that B E equals the diameter of the earth (i. e., B E = 2 R). By geometry.

$$BD : BA :: BA : BE\text{; whence } BE = \frac{BA^2}{BD}$$

Now B A is one mile, and B D equals two-thirds of a foot, or $^1/_{7920}$ of a mile; hence B E equals

$$\frac{1^2}{\frac{1}{7920}} = 7920 \text{ miles.}$$

On account of refraction, however, the result cannot be made exact. The necessary correction is large, and varies with the thermometer and barometer; so that the actual observed length of B D instead of being 8 inches, ranges from 5 to 7 according to circumstances.

At the time of Copernicus the only argument he could adduce in favor of the earth's rotation was that the hypothesis is much more probable than the older one, that the heavens themselves revolve. All the phenomena then known would be sensibly the same on either supposition. The apparent diurnal motion of the heavenly bodies can be fully accounted for (within the limits of the observations then possible) either by supposing that the stars are actually attached to a celestial sphere which turns daily, or that the earth itself rotates upon an axis; and for a long time the latter hypothesis did not seem to most people so probable as the older and more obvious one.

A little later, after the telescope had been invented, analogy could be adduced; for with the telescope we can see that the sun, moon, and many of the planets are rotating globes. Within the present century it has become possible to adduce experimental proofs which go still further, and absolutely demonstrate the earth's rotation; some of them even make it visible.

Foucault's Pendulum Experiment.—Among these experimental proofs the most impressive is the pendulum experiment devised and first executed by Foucault in 1851. From the dome of the Pantheon in Paris, he hung a heavy iron ball about a foot in diameter by a wire more than 200 feet long (figure 57). A circular rail some twelve feet across, with a little ridge of sand built upon it, was placed in such a way that a pin attached to the swinging ball would just scrape the sand and leave a mark at each vibration. To put the ball in motion it was drawn aside by a cotton cord and left to come absolutely to rest; then the cord was burned off, and the pendulum started to swing in a true plane. But this plane seemed to deviate slowly towards the right, so that the pin on the pendulum-ball cut the sand-ridge in a new place at each swing, shifting at a rate which would carry the line completely around in about 32 hours, if the pendulum did not first come to rest. In fact the floor of the Pantheon was actually and visibly turning under the plane of the pendulum vibration. The experiment created great enthusiasm at the time, and has since been frequently performed.

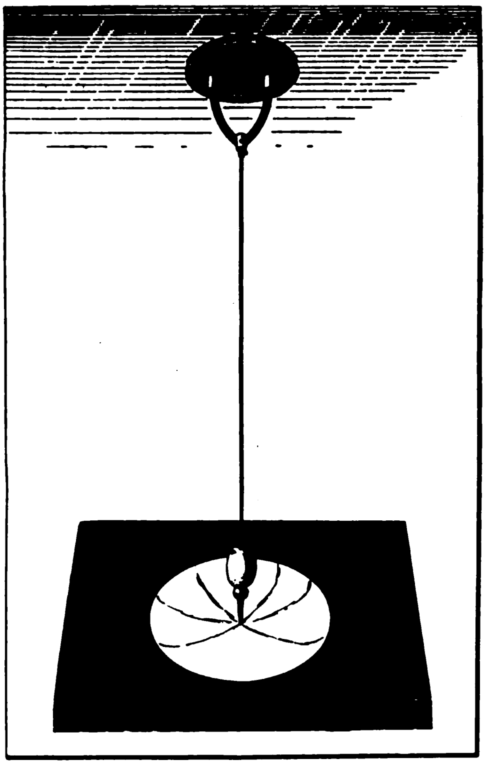


Figure 57.

Invariability of the Earth's Rotation.—It is a question of great importance whether the day ever changes its length. Theoretically, it must almost necessarily do so. The friction of the tides and the deposit of meteoric matter upon the earth both tend to retard the earth's rotation; while, on the other hand, the earth's loss of heat by radiation and the consequent shrinkage must tend to accelerate it and to shorten the day. Then geological causes act some one way and some the other. At present we can only say that the change, if any change has occurred since Astronomy became accurate, has been too small to be detected.

The day is certainly not longer or shorter by the $^1/_{100}$ part of a second than it was in the days of Ptolemy; probably it has not changed by the $^1/_{1000}$ part. The criterion is found in comparing the times at which celestial phenomena, such as eclipses, transits of Mercury, etc., have occurred during the range of astronomical history. Professor Newcomb's investigations in this line make it highly probable, however, that the length of the day has not been absolutely constant during the last 150 years.

Gravity.—What is technically called "gravity" is not simply the attraction of the earth for a body upon its surface, but the resultant of the attraction combined with this centrifugal force. It is only at the equator and at the pole that "gravity" is directed strictly towards the earth's center. Lines of level are always perpendicular to "gravity," and they are, therefore, not true circles around the earth's center. If the earth's rotation were to cease, the Mississippi River would at once have its course reversed, since the mouth of the river is several thousand feet further from the center of the earth than are its sources.

Accurate Determination of the Earth's Dimensions.—The form of the earth, instead of being spherical, is much more nearly that of an "oblate spheroid of revolution" (an orange-shaped solid) quite sensibly flattened at the poles; the polar diameter being shorter than the equatorial by about $^1/_{295}$ part. According to "Clarke's Spheroid of 1866" (which is adopted by our Coast and Geodetic Survey as the basis of all calculations) the dimensions of the earth are as follows:

Equatorial radius,	(a)	6,378,206.4 metres	=	3963.307 miles
Polar radius,	(b)	6,356,583.8 metres	=	3949.871 miles
		21,622.6 metres	=	13.436 miles

These numbers are likely to be in error as much, perhaps, as 100 metres, and possibly somewhat more; they can hardly be 300 metres wrong.

This deviation of the earth's form from a true sphere is due simply to its rotation, and might have been cited as proving it. The centrifugal force caused by the rotation modifies the direction of gravity everywhere except at the equator and the poles so the surface necessarily takes the spheroidal form.

Methods of Determining the Earth's Form.—There are several ways of doing this; one by measurement of distances upon its surface in connection with the latitudes and longitudes of the points of observation. This gives not only the form, but the dimensions also; i. e., the size in miles or metres. Another method is by the observation of the force of gravity at various points —observations which are made by means of a pendulum apparatus of some kind, and determine only the form of the earth, but not its size.

The simplest form of the method by actual measurement is that in which we determine the length of degrees of latitude, some near the equator, and others near the poles, and still others intermediate.

If the earth were exactly spherical, the length of a degree would, of course, be everywhere the same. Since it is not, the length of a degree will be greatest where the earth is most nearly flat; i. e., near the poles; in other words, the distance between two points on the same meridian having their plumb-lines inclined to each other at an angle of one degree will be greatest where the surface is least curved.

The measurement of an "arc" involves two distinct sets of operations, one purely astronomical, the other geodetic. Having selected two terminal stations several hundred miles apart, and one of them as nearly as possible due north of the other, we must determine first the distance between them in feet or metres, and second (by astronomical observations), their difference of latitude in degrees, with the exact azimuth or bearing of the line that connects them.

The Length of a Degree of Latitude.—The geodetic and astronomical observations thus give the length of the line Ah, both in feet and in degrees, so that we immediately find the number of feet in that degree of latitude which has its middle point halfway between A and h. If the earth were spherical, the length of a degree would be everywhere the same, and the earth's diameter would be found simply by multiplying the length of one degree by 360 and dividing the product by 3.1415926.

More than twenty such arcs have been measured in different parts of the world, varying in length from 25° to 2°, and it appears clearly that the length of the degrees increases towards the pole.

At the equator,	one degree	=	68.704 miles
At lat. 20°	one degree	=	68.786 miles
At lat. 40°	one degree	=	68.993 miles
At lat. 60°	one degree	=	69.230 miles
At lat. 80°	one degree	=	69.386 miles
At the pole,	one degree	=	69.407 miles

The difference between the equatorial and polar degree of latitude is more than seven-tenths of a mile, or over 3,500 feet; while the probable error of measurement cannot exceed a foot or two to the degree.

(To be continued.)

Press Ill. Svce.

The Hun flag has been at half mast on this submarine since she was captured by the British, while engaged in her nefarious task of mine laying in the path of transports. Just fore and aft of the base of the conning tower may be seen the mines, lashed in cradles, as they are carried into the zone of operations. On a level with the head of the man on the "bridge," and slightly to the left, is the lower spreader of the wireless aerial, the other end of which is suspended from the mast. While this submersible is of a type smaller than those which have been operating in American waters, the view is interesting because of the daily more patent fact that a portion of the destruction to shipping in our waters has been effected by means of mines similar to those here illustrated

Navigation News

America's first quantity output of concrete ships will be a fleet of tankers for the fuel oil trade. There will be 14 of them, aggregating 105,000 tons. Plans for these additions to the merchant marine have been announced by the concrete ship division of the Shipping Board. The concrete ship program also has been enlarged to provide for the construction of four smaller vessels, aggregating 12,500 tons, and 40 additional ones of 7,500 tons each.

More Concrete Ships Ordered

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July 4 will be launching day in American shipyards. Builders of the new merchant marine, from Maine along the Atlantic, Gulf and Pacific coasts to Seattle, Wash., and throughout the Great Lakes district, are asked to speed the production of ships, so as to have at least one vessel ready for launching on the anniversary of the Declaration of Independence.

Fourth of July A Ship Day

If this plan, suggested by Edward N. Hurley, Chairman of the United States Shipping Board, proves a success, July 4, 1918, will be the greatest ship launching day in the history of the world. It is hoped that President Wilson will take cognizance of the event and participate in the launching ceremonies at one of the shipyards.

Chairman Hurley has sent a telegram to all the yards, asking that every effort be made to have at least one Emergency Fleet vessel ready for launching on America's natal day.

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Evidence of an awakened interest in building the bridge of ships to France is manifest not only in tabulated reports showing the output of the yards for certain periods, but in reports reaching the officials of the Emergency Fleet Corporation direct from among the men in the ranks.

300,000 Shipyard Employees

From the official point of view it is interesting to know that the number of shipyard employees has passed the 300,000 mark. On October 7, when the keeping of records was first begun, there were 106,900 employees according to information supplied by Meyer Bloomfield, head of the Industrial Service Section. In seven months the number of workers has been increased by nearly 200,000—to be exact, 193,000. This fact speaks for itself as to whether the workingmen of the nation have been interested by the cry for ships.

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Song of the Shipbuilder

We work in the oldest stuff of the world—
Water and iron and fire and air.
And the courage of men with a flag unfurled,
To build a bridge from here over there.

With a fleet of ships we'll span the sea,
To carry supplies to you in France—
Guns and food and T. N. T.—
And whatever you need for the big advance.

And what's the difference where we work—
At a bench with a hammer, or a trench at the front?
We all are needed and will not shirk;
We are done with delays! Count us in at the hunt.

And what's the difference how we fight—
With blood or money, labor or guns?
We'll keep the bridge building day and night,
Till we trestle the sea to get to the Huns.

And what's the difference where you are?
We're all on the job with a will to win;
So, boys, do your bit with your gun in the war;
We're doing our bit with the rivet machine.

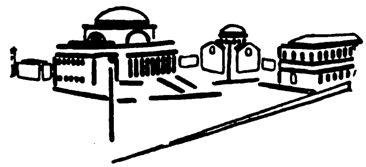
We'll keep the bridge building night and day;
We'll speed up ahead of the submarine.
We'll build to you, boys, so keep 'em at bay;
We're doing our bit with the rivet machine.

Boys, keep up your courage, we're getting to you,
Khaki or overalls, count us all in—
Knapsacks or dinner pails, we're fighting, too,
And doing our bit with the rivet machine.

In camp or the shipyard we all of us swear
That the hope ye are building will span to Berlin;
We're all of us soldiers, to do or to dare;
And we're doing our bit with the rivet machine.

LOUIS K. ANSPACHER.

Progress in Radio Science



A Generator of Sustained Oscillations

J. BETHENOD has recently perfected a powerful vacuum tube generator for undamped oscillations based upon the cathodic radiation from such substances as alkaline earthy oxide, lime, etc., or perhaps ultra-violet light.

With the apparatus shown in figure 1, the inventor claims to have produced a more powerful generator of sustained oscillations by the use of a single bulb than has heretofore been possible. He remarks that the vacuum is preferably as high as possible for satisfactory operation of the system. Referring to the diagram, a direct current generator is shown at 3, a shunt condenser at 9, the envelope or the vacuum tube at 1, two parallel plates at 4 and 4′, a cathode at 2, and 2 electrodes 5 and 5′. The coil 6, is placed in inductive relation to coil 7 which is in turn shunted by the variable condenser 8. The operation of the system follows:

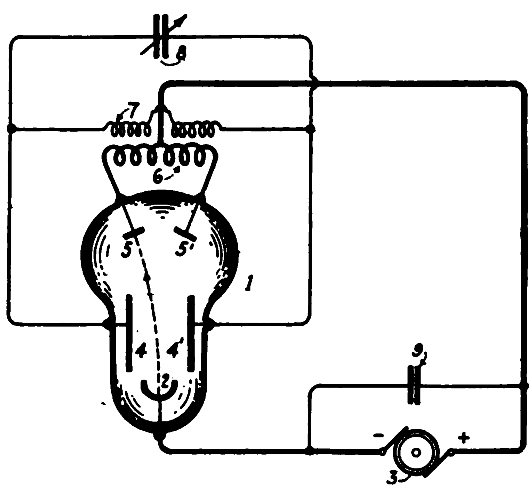


Figure 1—Powerful generator of sustained oscillations by the use of a single bulb

Because of the accelerating action of the field created by the generating dynamo 3 between the cathode 2 and the two electrodes 5 and 5′ the negative charges emitted pass between two plates 4 and 4′, which form, in a sense, the coatings of a condenser. These are connected to the ends of one winding 7 of a transformer, of which the other winding 6 has its middle point connected to the positive pole of the generating dynamo 3. Under these circumstances, the condenser formed by the plates 4 and 4′ is charged sufficiently to concentrate the cathodic beam on the anode 5′. This displacement causes a reversal of the electric field, and results finally in the cathode beam being deflected very rapidly between the anodes 5 and 5′. The continual reversal of the electro-motive force thus induced in the coil 7 may be utilized by arranging for example a condenser 8 across the terminals of the generator 3 to obviate the passage of any high-frequency current. As a protection to the generator, condenser 9 may be shunted across the terminals.

A Variable Condenser and Inductance for a Receiving Circuit

IT is desirable in such apparatus as decremeters, tuning condensers, etc., that the capacity of the condenser increase directly with the position of the movable plates.

The usual variable condenser used in tuning radio receiving apparatus consists of a set of movable plates and stationary plates of semi-circular sections. As is well known, such a condenser does not give equal increments of capacity for equal angular displacements of the plates. Several inventors have designed variable condensers of various forms in which the desired increment of capacity is obtained, but one particular construction recently evolved by F. Lowenstein to constitute the variable element of an oscillation circuit is shown in figure 2.

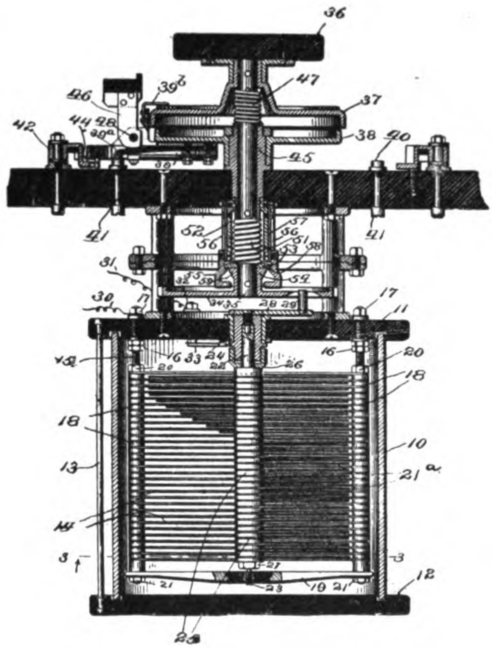


Figure 2—Vertical section of the cut off plate condenser connected mechanically to a variable inductance

In order that the same percentage change in capacity C may be produced by a given displacement of the movable plates at any point X on the characteristic or operating curve of the instrument, it is necessary that

$$\frac{C_n - C_{n-1}}{C_{n-1}} = \frac{C_{n+1} - C_n}{C_n}$$

whence

$$C_{n^2} = C_{n-1} C_{n+1}$$

or

$$C_n = \sqrt{C_{n-1} C_{n+1}}$$

The variations in capacity of the condenser must therefore follow the law of geometrical progression. The equation of the characteristic can be deduced from this consideration, and may take the form

$$C = a \left(\frac{b}{a} \right)^{\frac{x}{d}},$$

where *a* and *b* are the lower and upper operating limits of the condenser capacity and *d* is the maximum displacement of the instrument.

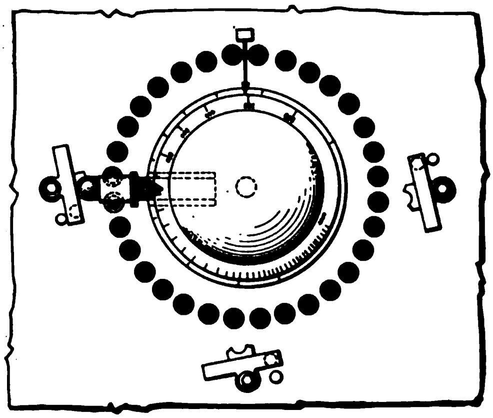


Figure 3—Plan of the apparatus shown in figure 2

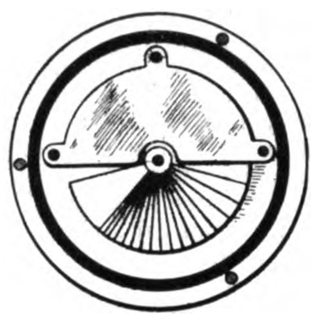


Figure 4—Transverse section of figure 2 viewed from below

An equal expression is derived from the fundamental consideration that

$$\frac{\Delta C}{C} = \text{a constant.}$$

By integrating and transforming,

$$C = pe^{nx}$$

where p and n are instrument constants, and e is the base of Napierian logarithms.

For a rotary condenser, such as is later described, the equation may be written

$$C = pe^{m\theta}$$

where θ is the angle of displacement in degrees.

From the foregoing it is evident that the active area of the movable surface of a condenser constructed in accordance with the invention, neglecting edge effects, is

$$A = qe^{m\theta}$$

In this equation the constants q and m influence the minimum and maximum capacity values and therefore the operating range of the condenser.

A condenser embodying the Lowenstein principles, giving the desired operating curve, can be made by making the superposed condenser plates semi-circular and of the same size as usual, while the movable plates are cut off at such different angles as to produce the desired logarithmic characteristic. In figure 2 is shown a vertical section of the cut off plate condenser which is connected mechanically to a variable inductance shown partly in elevation. Figure 3 is a plan of the apparatus shown in figure 2 and figure 4 is a transverse section of the line 3—3 of figure 2, viewed from below, the casing having been removed. It will be seen that the movable plates, with the exception of a few at the top of the set which are fully semi-circular are cut off at angles which are progressively graded from the top downward. As a result, the edges of the movable set of plates are arranged in step-like fashion, so that they enter successively between the stationary plates as the shaft is turned. The proportioning of the plates and their arrangement is such that the capacity of the condenser is variable substantially in accordance with the logarithmic law previously given. Futhermore, the change in capacity is much more gradual than in a condenser of other known types.

The condenser shown in figure 2 is associated with a variable inductance element, also logarithmic in character, in such a manner that both inductance and capacity may be varied together in a reciprocal relation, or each may be varied independently.

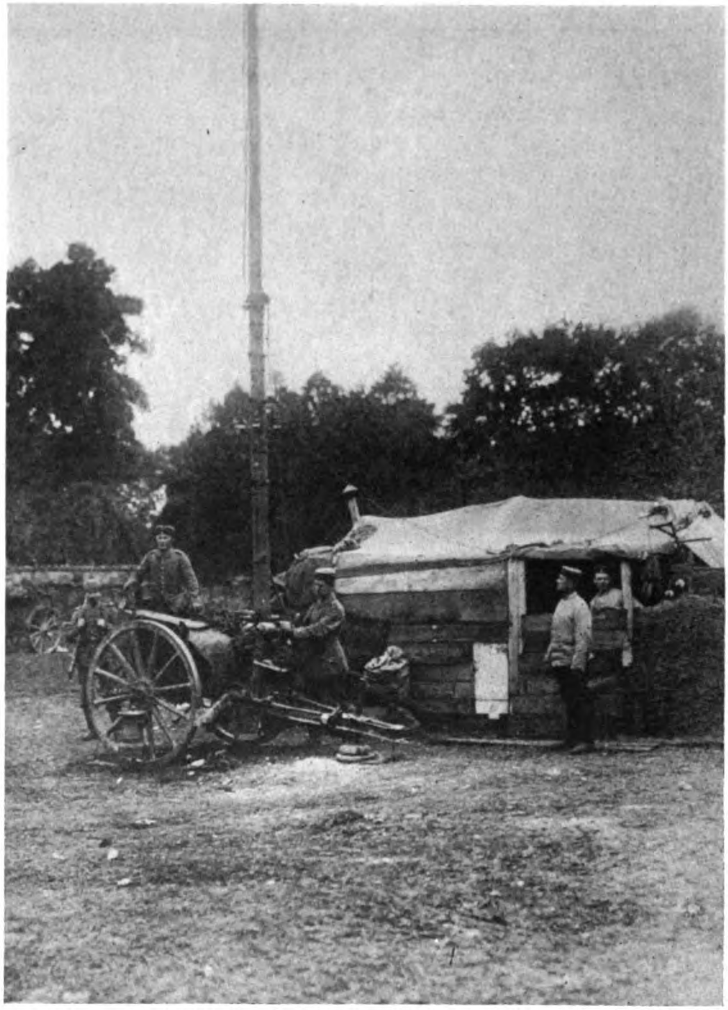
The mechanism will be briefly described, however, for the sake of clearness.

In the arrangement illustrated, the movable part of the condenser is turned by means of the crank 28, crank pin 29, crank disk 34, vertically movable shaft 35, and rubber knob 36. Attached to the shaft 35 is an upper clutch disk 37. To a lower clutch disk 38 is attached a self-inductance arm 39 carrying brush 39^a and wave length pointer 39^b, the brush being arranged to make contact successively with the contact points 40, these latter being electrically connected by means of studs 41 and suitable leads with the tapping-off points of a suitable self-inductance coil (not shown). At 42 are pivotally mounted switches, each provided with a bifurcated projecting portion 43 so disposed that one or the other of the arms of the portion always lie in the circular path traversed by actuating stud 44 carried by the self-inductance arm. As the self-inductance arm is moved in counter-clockwise direction, the self-inductance increases, the stud acting successively on the switches 42 to cut in additional sections of the inductance coil. The lower clutch disk 38 is arranged to be turned individually on a post 45 by means of a handle 46. Spring 47 surrounding the vertically movable shaft 35 is compressed between the upper end of post 45 and the upper clutch disk 37, thereby tending to maintain the clutch members out of mutual engagement. Handle 46 is here shown as pivoted at 48, whereby it may be turned down to press brush 39^a into firm contact with any of the contact points.

Both the condenser and the self-inductance can therefore be varied independently, as for example in tuning a wireless circuit. Once tuning has been accomplished, the rubber knob 36 may be pushed down to engage clutch 37-38, and turning of the knob will then cause an equal angular displacement of the capacity and of the self-inductance. The capacity scale 49 and wave length scale 50 are both carried by the upper clutch member 37. Stationary pointer 49^a indicates the capacity readings, while wave lengths are indicated by the pointer 39^b, before mentioned. In the present instance, clockwise movement of the knob, when the clutch is engaged, causes the capacity to increase and the self-inductance to decrease. To obviate the necessity of holding the knob 36 depressed during the turning of the coupled elements, a compression spring 51 is provided to keep the clutch members in engagement. This spring is confined between the lower end 52 of stationary post or sleeve 45 and washer 53, which latter rests on the hub 54 of the crank disk 34, the crank disk being secured to the vertically slidable shaft 35. The spring therefore tends to force the shaft downwardly to bring the clutch members into mutual engagement and thereby to mechanically couple the inductance and capacity elements. The spring is of sufficient strength to overcome the opposing spring 47. In the position of the parts here shown, spring 51 is prevented from depressing the upper clutch member by means of latch members 55 which are carried on leaf springs 56 secured to a sleeve 57. The leaf springs press the latch members inwardly so that their shoulders 58 may engage the under side of the washer 53. When the knob 36 is pushed down, the sloping cam surfaces 59 of the crank disk hub throw the latches 55 outwardly, thereby releasing washer 53 and the spring 51 confined thereby, the clutch being thereafter held in engagement by the spring.

Next Month

The Pan-American Wireless Project



Press Ill. Svce.

During the course of forty years' preparation for war, Fritz invested a lot of money in wireless apparatus which has had doubtful utility in service. The telescopic mast illustrated above fulfills all expectations as to quick erection, but proved an excellent mark for the practice of allied artillery. Considerations of weight and difficulties in portability made this type of mast practical only for division headquarters use, whereupon it became very useful to our gunners in aiding the shelling of Hun major generals. The outfit, as a matter of fact, was designed to accompany the high Hindenberg disciples on the march, since slightly delayed, which was to end with a joyous crackling of congratulations from Paris to Berlin.

Press Ill. Svce.

Contrary to the impression first gained of the picture, it is not that of a posed group, but represents the temporary suppression of activities by a French signal detachment at Verdun. Heavy shelling having cut off wire communication, these men were detailed to establish a signal station for daylight signaling by searchlight beam. The messenger has just delivered a dispatch, which is being read while the man with the pipe is deciphering the message which the soldier seated is writing. However, no immediate problem concerns the soldier standing near the rifles greater than solving the assembly of the "makin's" of a cigarette. Hustle and bustle are always associated with war in the popular mind and once again in this picture, as in many others from the zone of operations, the calm assurance of the fighting men makes it difficult to realize how actively engaged are the French signalists in providing continuous communication between all arms of the service and to field commanders.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XV

By Elmer E. Bucher

Director of Instruction Marconi Institute

Editor's Note—This is the fifteenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of The Wireless Age. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

ERRATA

In the June issue, page 755, the three last lines of the paragraph following the title "OPERATION," should have read as follows:

termination of a wave train leaks to earth through the head telephone, impulsing the telephone diaphragm once for each group of incoming oscillations. A circuit of this kind does not possess the tuning qualities of the coupled circuits.

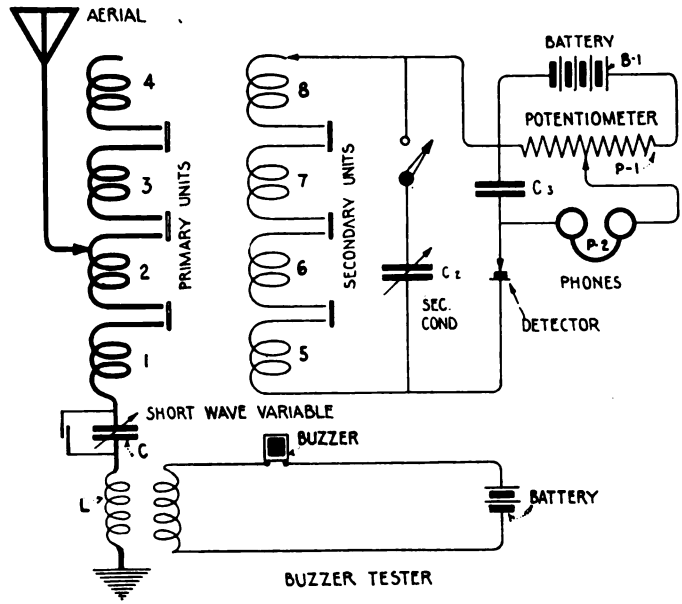


Figure 133

OBJECT OF THE DIAGRAM

To show the fundamental circuits of the type 106 receiving tuner (of the American Marconi Company) using a crystal rectifier.

DESCRIPTION OF THE DRAWING

The **primary circuit** comprises the inductance units 1, 2, 3, 4, the short wave variable condenser C, and the small coupling coil L. The **secondary circuit** embraces the inductance units 5, 6, 7, 8; the secondary shunt condenser C-2, the battery B-1, the potentiometer P-1, the telephone P-2, and the telephone condenser C-3. A buzzer **excitation system** includes the coil L-1, the buzzer B-2, and the battery B-3.

The **coupling** between the primary and secondary coils is varied by means of a gear rack controlled by a knob mounted on the front of the tuner cabinet. It has a scale marked from zero to ten.

The **inductance of the primary circuit** is varied by means of two multipoint switches, one of which operates in conjunction with a switch barrel which disconnects the unused turns of the primary winding for any particular wave length.

The four groups of the primary (1, 2, 3, 4) are cut into the circuit progressively as the wave length is increased. The aerial tuning inductance is included in the **"tens"** switch of the primary winding. The **"unit"** switch controls ten single turns of the primary coil permitting any number from one to maximum to be included in the antenna circuit. The **short wave variable condenser** is automatically short-circuited when moved slightly beyond the 180° position on the scale.

The secondary coil also is fitted with an **end turn switch** which splits the winding into three groups. The secondary variable condenser in the zero position is disconnected from the circuit, thereby eliminating the capacity effect between opposite plates when the pointer is in the so-called "zero" position of capacity.

A special wire-wound **potentiometer** is supplied, having resistance of about 450 ohms. This is adjusted by a rotary multipoint switch. The receiving **detector** is mounted on the front of the panel (see figures 134 and 135). It consists of a steel contact point mounted on an arm which is supported by a universal joint. The steel point may be placed in contact with any spot in the crystal, which is mounted in a cup underneath.

OPERATION

The primary and secondary circuits of the receiving tuner may be calibrated by a wave meter, so that the operator can pre-adjust the apparatus to any desired wave length.

The primary circuit cannot be calibrated until the apparatus is connected to an aerial because the capacity and inductance of ships' aerials differ widely. It is therefore evident that a primary winding with given dimensions will afford different wave length adjustments with different aerials.

In event that the secondary circuit is calibrated in wave lengths, the operator may **select the correct inductance and capacity** for the desired signal. He then places the secondary winding in partial inductive relation to the primary winding following this by **varying the capacity and inductance** of the antenna circuit until response is secured. The **potentiometer is now re-adjusted,** new points on the crystal rectifier are tried, with simultaneous **variation of the coupling** of the receiving transformer, until the loudest possible signals are secured.

If a scale of wave lengths for the receiving tuner is not supplied, resonance can be established with a given transmitter in the following manner:

(1) Set the secondary circuit approximately to the required wave length using large values of inductance and small values of capacity;

(2) Couple closely the secondary coil to the primary coil;

(3) Increase (or decrease) the inductance in the antenna circuit until response is obtained in the head telephone;

(4) Adjust the detector to maximum sensitiveness by the potentiometer;

(5) Adjust the detector for maximum strength of signals or until interference is eliminated;

(6) Reduce the coupling of the receiving transformer;

(7) Try other values of secondary inductance and capacity; similarly for the antenna circuit.

SPECIAL REMARKS

(1) Selectivity, that is, discrimination between interfering stations depends markedly upon the coupling of the receiving transformer. If the primary and secondary coils are **coupled closely,** a greater amount of energy will be extracted from the incoming oscillations than with lesser coupling. This will increase the damping. The antenna circuit will under these conditions act as an oscillation circuit whose resistance has been increased, namely, **it will respond to frequencies slightly off the fundamental frequency of the circuit.**

(2) If, on the other hand, the primary and secondary circuits are coupled **loosely,** smaller amounts of energy will be extracted from the antenna oscillations. The antenna will therefore oscillate with **greater persistence** and will only respond with freedom to waves the **frequency of which coincides with its natural frequency of oscillation.**

(3) In summary, if the two circuits are **closely coupled, broad tuning** will result, or if **loosely coupled, sharp tuning** will result. In other words, when the receiving transformer coils are loosely coupled **a small change of inductance or capacity will eliminate the signals from a given station, but when tightly coupled a much greater change of inductance or capacity will be required to eliminate the signals.**

(4) We may say in general, that an advancing wave of feeble decrement permits the primary and secondary circuits to be loosely coupled, but a highly damped wave requires these circuits to be closely coupled.

(5) If only small inductances are required at the base of the receiving aerial to establish resonance with the transmitter, sharper tuning will be secured by connecting a variable condenser in series, adding inductance until resonance with the desired wave is secured. This tends to decrease the natural decrement of the receiving antenna but generally results in a decrease in the strength of signals. The loss of signal strength, however, is more than compensated for by the degree of selectivity obtained.

(6) In general, more accurate tuning or great selectivity is secured in the secondary circuit when the shunt variable condenser is worked at small values of capacity with correspondingly large values of inductance. But if loose coupling is employed, greater values of capacity and lesser values of inductance may give increased selectivity.

(7) In summary, interference can be prevented:

(1) By employing loose couplings between the primary and secondary coil;

(2) By inserting a condenser in the antenna circuit and adding inductance until resonance is secured for a given wave length.

(8) As the transmitter operates at approximately the wave length to which the secondary circuit of the receiver is adjusted it produces strong signals, which are liable to impair the sensitiveness of the crystal. To obviate this, connections are made with the antenna switch so that when it is in the transmitting position, the terminals of the detector and secondary condenser are short-circuited. Care should be taken to

see that the antenna switch with which this receiver is to be used is constructed so as to perform the above operations. If this is done, the transmitter has very little or no effect on the sensitiveness of the crystal, and it will therefore be in a sensitive condition for receiving immediately after transmission.

Figure 134—Front view of the Marconi type 106 receiving tuner. The two switches on the front marked "Transformer Primary" vary the inductance of the primary circuit. The switch marked "units" cuts in a single turn of the primary coil at a time. The switch marked "tens" varies the primary inductance in groups of ten turns at each point of contact. The primary condenser is connected in series with the antenna circuit. The switch marked "transformer secondary" and the control handle marked "secondary condenser" control the inductance and capacity of the secondary circuits. The control handle marked "potentiometer" varies the flow of current through the detector. The switch marked "battery" turns the local battery current on and off. These terminals are connected to four dry cells in a separate box. The terminals marked "telephones" are the binding posts for connections to 2,000 ohm telephone receivers.

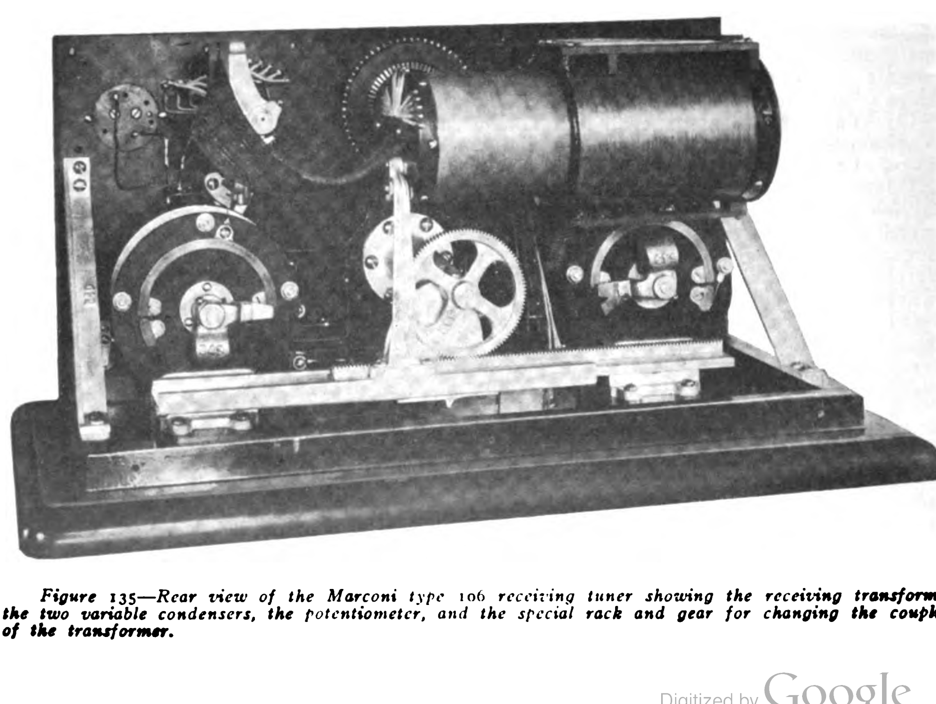


Figure 135—Rear view of the Marconi type 106 receiving tuner showing the receiving transformer, the two variable condensers, the potentiometer, and the special rack and gear for changing the coupling of the transformer.

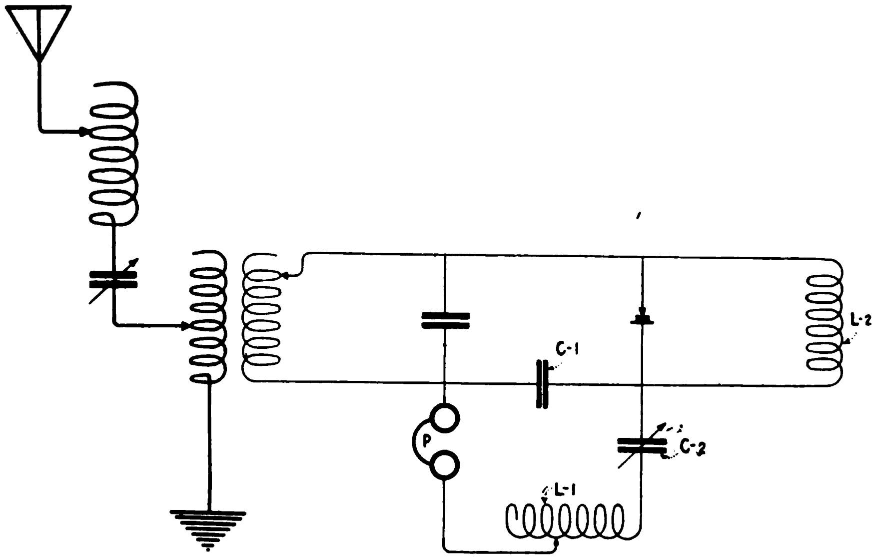


Figure 136—Showing the circuits of the group frequency tuner developed by the American Marconi Company. A fixed condenser C-1, a variable condenser C-2, the variable inductance L-1, and the telephone P constitute a circuit which is selective to audio frequencies. The receiver therefore may be tuned to the group frequency of the transmitter as well as to the incoming radio frequency current. Additional selectivity is thus afforded. The coil L-2 shunted across the detector amplifies the incoming signal considerably. The inductances L-2 are approximately 1,000 times the inductance of the secondary coil. Inductances L-1 and L-2 are approximately of the same dimensions.

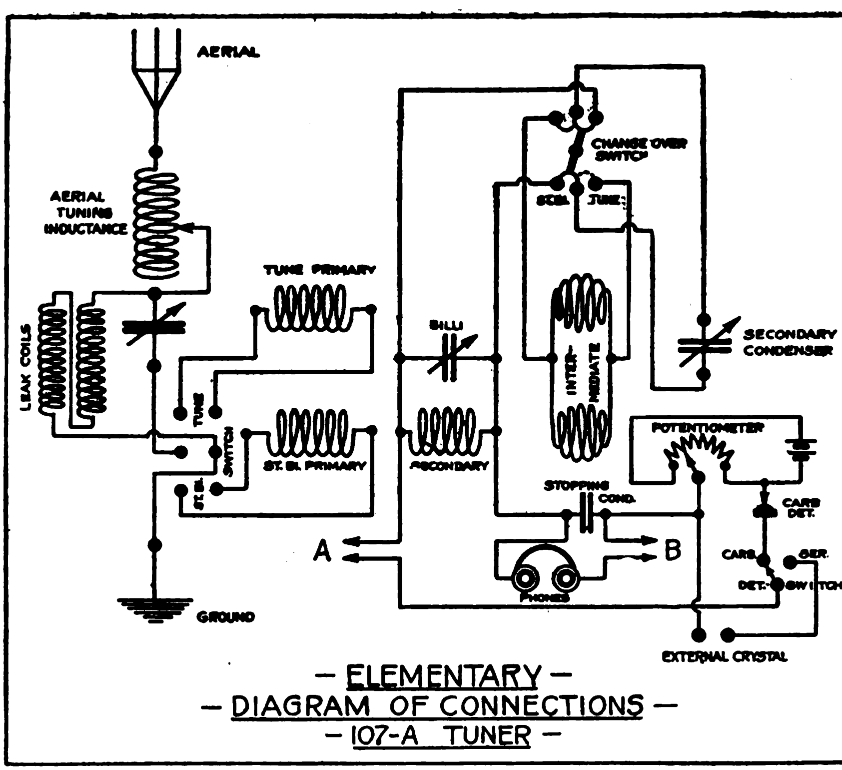


Figure 137.

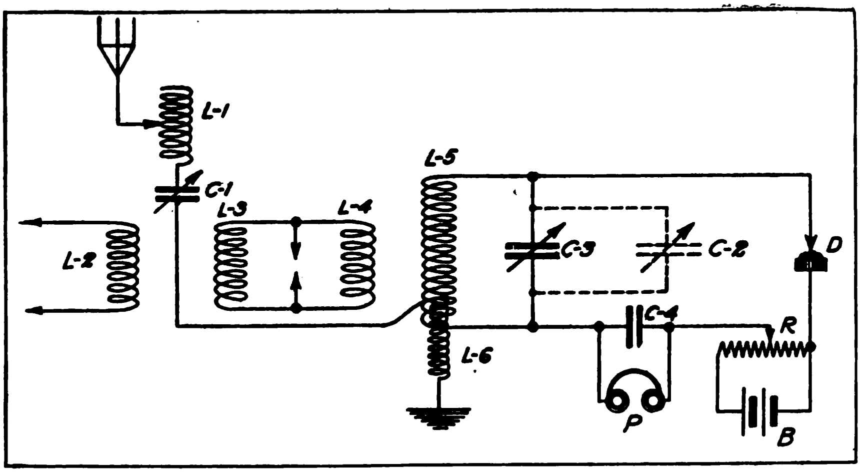


Figure 138.

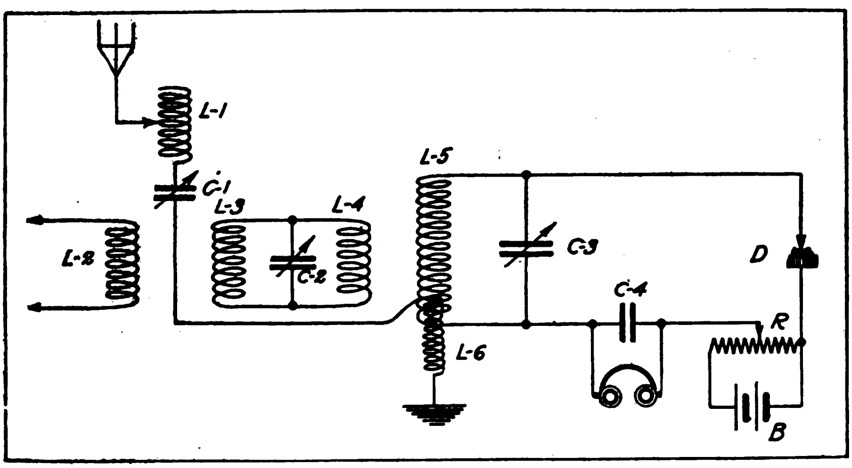


Figure 139.

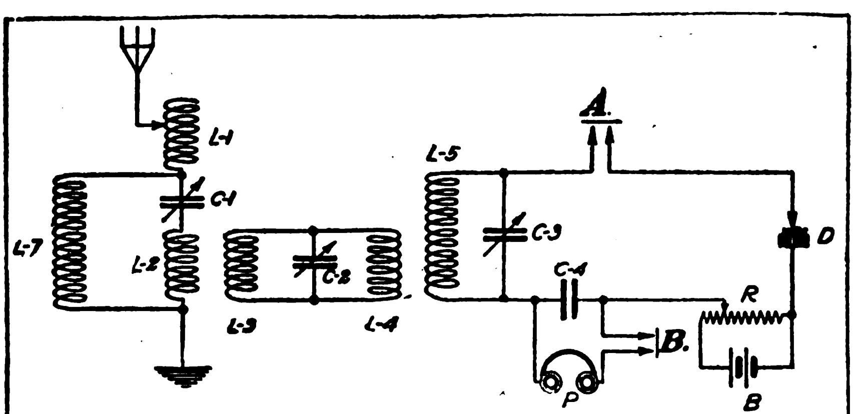


Figure 140.

OBJECT OF THE DIAGRAMS

(1) Figure 137. To indicate the complete connections of the type 107a receiving tuner of the American Marconi Company.

(2) Figure 138. To show the connections of the "stdbi" long wave adjustment of the type 107a tuner.

(3) Figure 139. To show the connections of the "stdbi" short wave adjustment of the type 107a tuner.

(4) Figure 140. To show the "tune" circuits of the type 107a tuner.

PRINCIPLE

A type of receiving tuner introduced into commercial practice about four years ago is fitted with what is termed an "INTERMEDIATE" tuning circuit which provides increased selectivity and aids in the elimination of static interference.

DESCRIPTION OF THE DRAWINGS

In figure 137 the **antenna circuit** comprises the aerial tuning inductance, the short wave variable condenser, two primary coils—one marked "tune primary," the other "stdbi primary"—and the inductive leak coils shunted around the primary circuit and the short wave condenser.

The **intermediate circuit** comprises the two windings (marked L-3, L-4 of figure 140) and a secondary condenser which can be placed in shunt to these two windings or in shunt to the billi condenser which ordinarily is connected across the secondary coil. This is effected by means of the **changeover switch** in the upper part of the drawing marked "stdbi" and "tune."

The **secondary or detector circuit** comprises the secondary coil, the shunt billi condenser (.0001 microfarad capacity) the stopping condenser, the potentiometer, batteries, carborundum detector, and a special detector switch so that either the carborundum or cerusite detectors may be employed. The telephone condenser is shunted by a telephone of about 2000 ohms resistance.

For protection from the local transmitter, the secondary circuits are opened at points A and B (figure 137) during transmission.

In figure 138 are shown the connections for the **"stdbi" long wave adjustment.** The primary coil L-6 is placed in close inductive relation to the secondary winding L-5, the primary coil L-2 and the coils L-3 and L-4 of the intermediate circuit being disconnected. The condenser which ordinarily shunts the intermediate circuit is now connected in shunt to the billi condenser C-3. This affords increased wave length adjustment.

In figure 139, the intermediate condenser C-2 is disconnected from C-3. Because of its capacity at the zero position on the scale it increases the wave length of the secondary circuit beyond the value desired. The tuner in this position is in proper adjustment for receiving **short waves with close coupling.**

In figure 140 are shown the complete "tune" circuits of the type 107a tuner, wherein the **primary, intermediate,** and **secondary circuits** complete are employed; that is, coil L-2 is placed in inductive relation to L-3, and coil L-4 in inductive relation to L-5.

OPERATION

With this tuner three possible circuits may be used. There is a **"stdbi" adjustment for (1) long and (2) short waves, and a (3) "tune" adjustment for short waves.** Connections from one to the other are made by means of the switch (figure 137) marked "change-over switch." When thrown to the right (on the actual apparatus) the primary, intermediate, and secondary circuits are in use, but when thrown to the left, the antenna coil marked "stdbi primary" is coupled directly to the secondary coil. A fixed coupling is employed. If, with the "stdbi" adjustment the condenser change-over switch is thrown to the position "stdbi," the intermediate condenser is connected in shunt to the billi-condenser across the secondary winding thereby permitting increased wave length adjustments.

With the **"stdbi" long wave adjustment** connections of figure 138 the primary winding L-2 is disconnected from the antenna circuit, and the secondary winding L-5 inductively coupled to L-6. L-6 is a fixed inductance wound tightly around the turns L-5 affording a very close coupling between the aerial and detector circuits.

It is clear that coil L-4 of the intermediate circuit is still in inductive relation to L-5, and the precaution should therefore be taken to turn the coupling knob to the zero position, for otherwise energy will be withdrawn from the detector circuit reducing the strength of the incoming signals. This absorption is more apt to take place when the intermediate condenser C-2 is connected across the inductances L-3 and L-4.

For tuning to waves up to approximately 1000 meters with "stdbi" connection, the billi-condenser only is employed. For longer wave lengths, the six-point double throw switch mounted on the top of the tuner (marked "change-over switch" in figure 137)

is placed in the "stdbi" long wave position. This connection permits waves up to 3,000 meters to be recorded.

The **"stdbi" short wave circuits** are shown in figure 139, the only difference between them and those of figure 138 being that the condenser C-2 is connected in shunt to the intermediate circuit. The condenser C-3 is employed to tune the secondary circuit to resonance. With this connection tuning is accomplished by setting the condenser switch at "tune," and the coupling knob (of the intermediate circuit) at zero; then carefully adjusting the billi condenser. Next connect in a few points of the aerial tuning inductance and vary the capacity of the short wave condenser until response is secured.

For **sharp tuning on the shorter wave lengths** below 1000 meters, place the double-throw knife switch on the "tune" position. Place the condenser switch on the "tune" position. Set the coupling knob of the intermediate circuit in the neighborhood of 70° to 90°. Add two or three points at the switch of the aerial tuning inductance. Adjust carefully the intermediate condenser. Follow this by varying the capacity of the short wave condenser and of the billi condenser until the loudest response is secured. In this position all the variable elements of the complete tuner are in use.

SPECIAL REMARKS

(1) It is important to note that the type 107a tuner is fitted with four binding posts at the rear from which connections extend to the type S, SH, or I aerial change-over switch. When this switch is placed in the transmitting position, the circuits of the 107a tuner are interrupted at the points A and B (figure 140) thus breaking the circuit to the detector and the head telephones. The contacts of the antenna switch must have careful inspection from time to time, for unless they close the circuits properly, the apparatus will not function. Should these contacts be broken, a permanent jumper must be placed across the binding posts to keep the circuit closed.

(2) The "stdbi" connections are employed when the operator is awaiting a call from one of several stations not accurately tuned to the same wave length. The "tune" connections are employed during periods of excessive interference.

(3) It is essential that the **polarity** of the detector battery be correct for the maximum strength of signals. This can only be determined by experiment. **The connections to the crystal should be reversed** and **the potentiometer adjusted** until the loudest signals are obtained from a given station.

(4) The type 107a tuner was originally designed for use with the Fleming valve, but it is now equipped for use with the carborundum detector solely. Two connections extend out from the base of the tuner immediately under the aerial tuning inductance to permit connection to an **external detector** such as cerusite.

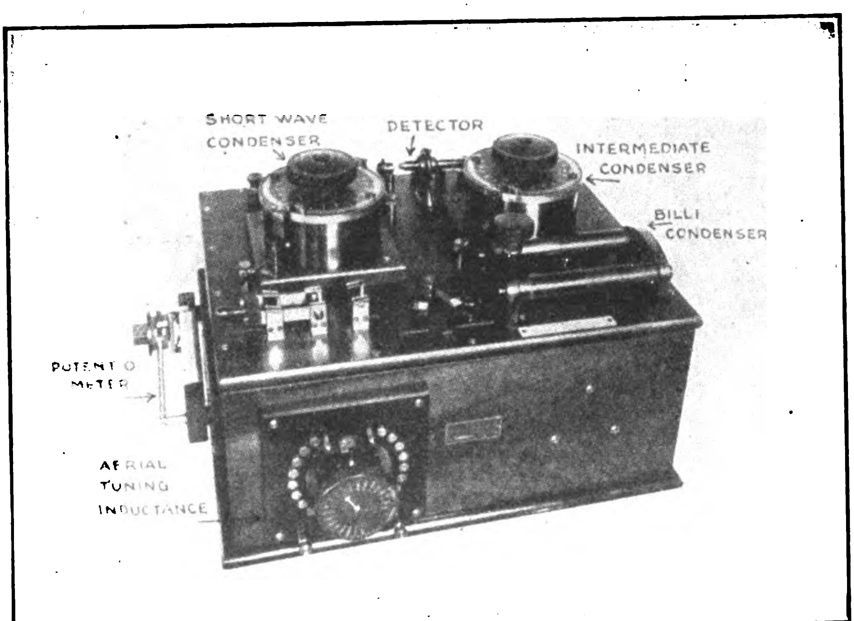


Figure 141—Showing the type 107a tuner. The photograph does not indicate the special condenser change-over switch which in practice is mounted between the short wave condenser and the intermediate condenser.

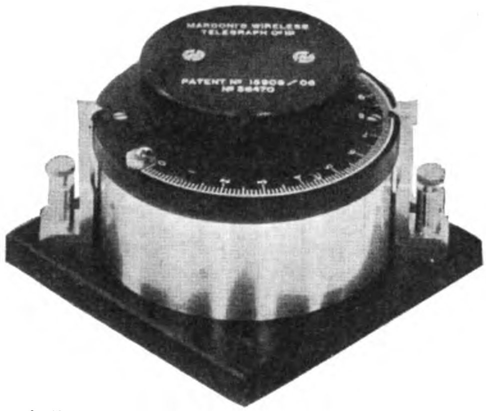


Figure 142—The Marconi disc variable condenser used in connection with the type 107a and the Fleming valve type of tuners. This condenser is of small dimensions for its capacity, which is .01 microfarad. It consists of a number of very thin steel plates separated from one another by thin sheets of hard rubber. Two semi-circular sets of stationary plates and two sets of movable plates are included in the design, thus permitting a large capacity to be obtained with a condenser of small dimensions.

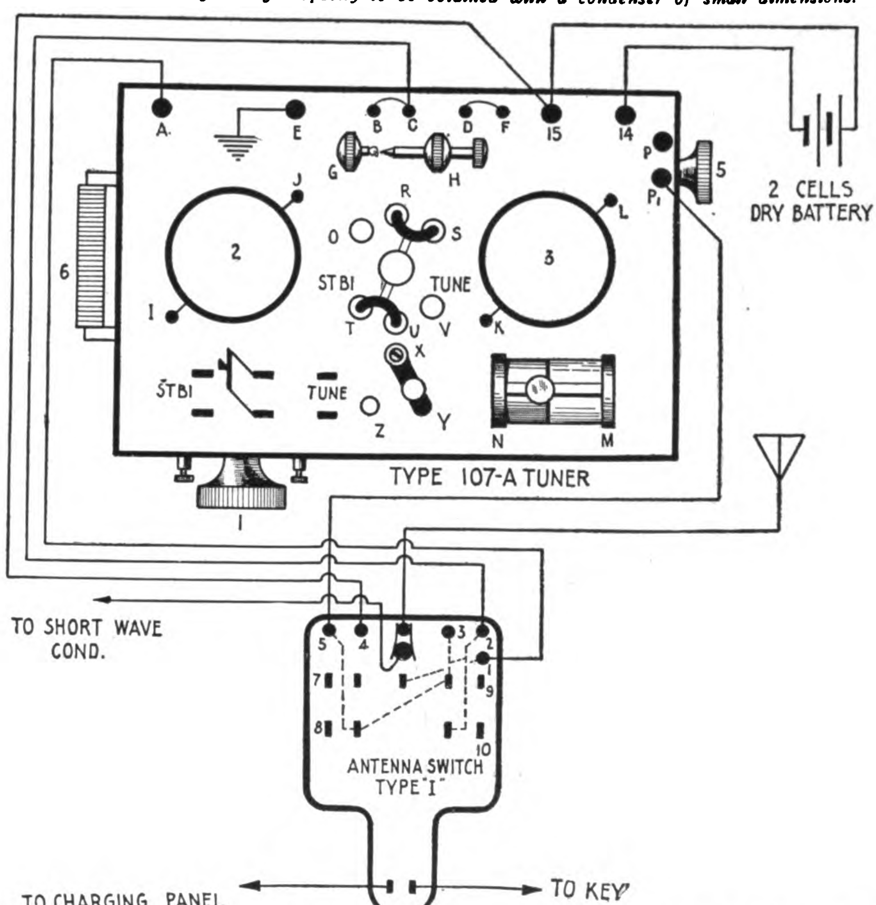
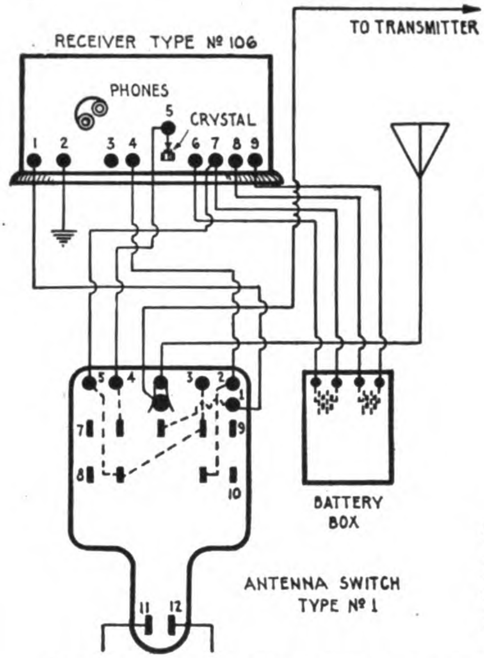


Figure 143—Showing the type I antenna change-over switch of the American Marconi Company connected to the type 107a receiving tuner. In this diagram, binding posts 2, 4, and 5, of the type I switch lead to contacts which short circuit the receiving detector and the receiving telephones during the transmitting schedule. It is to be noted that with this switch, the detector and telephone circuits are on short circuit rather than being open as in the type S switch; also the binding posts B and C, D and F, are connected together by jumpers. The other notations of this sketch are as follows: 2 is the antenna short wave condenser; 3 is the intermediate circuit condenser; NM is a billi condenser, 5 the coupling knob for the intermediate circuit; 1, the knob for the aerial tuning inductance, and 6, the potentiometer. The condenser change-over switch is indicated by the contacts ORS, and TUV.



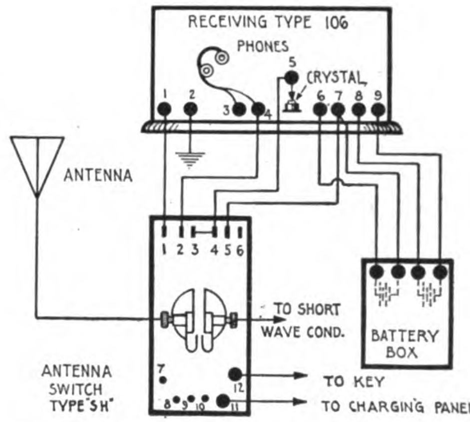


Figure 145—Showing the connections of the type SH, aerial change-over switch connected to the type 106 receiving tuner. The binding posts 1, 2, 3, 4, and 5 of the type S H, antenna switch lead to contacts which place the head telephone and detector of the type 106 tuner on short circuit. Binding posts 11 and 12 close the circuit to the primary winding of the transmitting high voltage transformer.

Figure 144—Showing the type I switch connected to the type 106 receiving tuner. The binding posts 2, 4, and 5, of the type I antenna switch short circuit the crystal detector and head telephones, during transmission. Binding post No. 1 connects to the aerial binding post No. 1 of the type 106 tuner. Contacts 11 and 12 close the circuit to the primary winding of the high voltage transformer. Binding posts 6, 7, 8 and 9 of the type 106 tuner are connected to the four binding posts of the battery box.

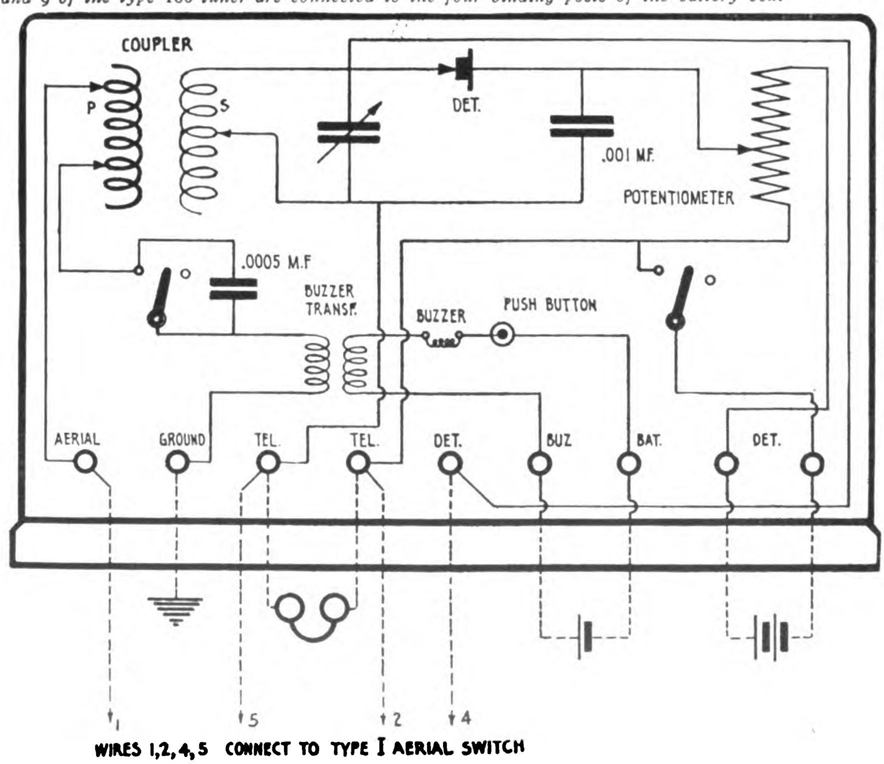


Figure 146

OBJECT OF THE DIAGRAM

To show the complete circuits of the type 112 receiving tuner (cargo ship type apparatus) of the American Marconi Company.

DESCRIPTION OF THE DRAWING

The tuner fundamentally is similar to the type 106, but it is somewhat simplified both in regard to construction and manipulation. It consists of the usual inductively coupled receiving transformer, but has **double-layer primary** and **secondary windings.** These give a maximum of inductance with a minimum of resistance for a coil of given dimensions.

The potentiometer and head telephones are connected around the condenser in series with the detector, the latter being shunted across the secondary circuit as usual. A buzzer tester is placed in inductive relation to the earth lead. The inductance of the primary winding is regulated by a "tens" switch and a "units" switch.

The inductance of the secondary winding is changed by a simple multipoint switch. The secondary shunt condenser consists of two concentric brass tubes which are telescoped by the movement of a small knob in the slot in the top of the tuner.

The coupling between the primary and secondary coils is changed by a knob sliding in the lower slot through the front of the panel.

When the knob is placed to the extreme left, the coupling is maximum; lesser degrees can be obtained by moving the knob in the opposite direction.

The series antenna condenser is thrown into the circuit by means of the switch marked "condenser-in -out." It is of fixed capacity, approximately .005 microfarad. Resonance is established by variation of the primary inductance.

The tuner is fitted with a carborundum detector, the latter being mounted immediately to the front of the panel. The local battery current for the crystal is turned on and off by the switch marked "battery-on -off." This switch always should be in the "off" position when the receiver is not in use.

OPERATION

The crystal is adjusted to sensitiveness by pressing the push button closing the circuit to the buzzer and placing the pointed contact upon various parts of the crystal until the loudest response is secured in the head telephones. Simultaneous adjustment of the potentiometer is made. In fact a different value of voltage must be applied for each new point of contact.

The complete tuner may be adjusted to incoming signals as follows:

(1) Adjust the detector by a buzzer tester;

(2) Place the coupling knob as far to the left as possible;

(3) Vary the inductance of the primary and secondary coils progressively until the desired station is heard;

(4) When signals are heard decrease the coupling;

(5) Re-tune the primary and secondary circuits using small values of capacity at the secondary condenser;

(6) Then change the coupling slightly until the loudest signals are secured or until an interfering signal is eliminated.

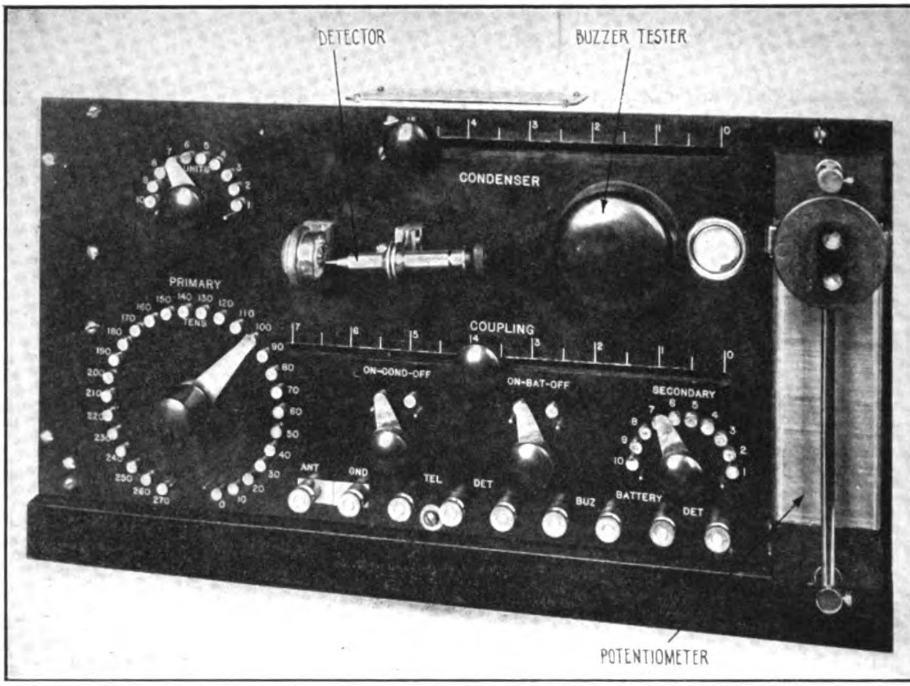


Figure 147—Front view of the Marconi type 112 receiving tuner showing the position of the primary and secondary inductance switches, the coupling knob, the secondary condenser knob, the carborundum rectifier, buzzer tester, and the potentiometer.

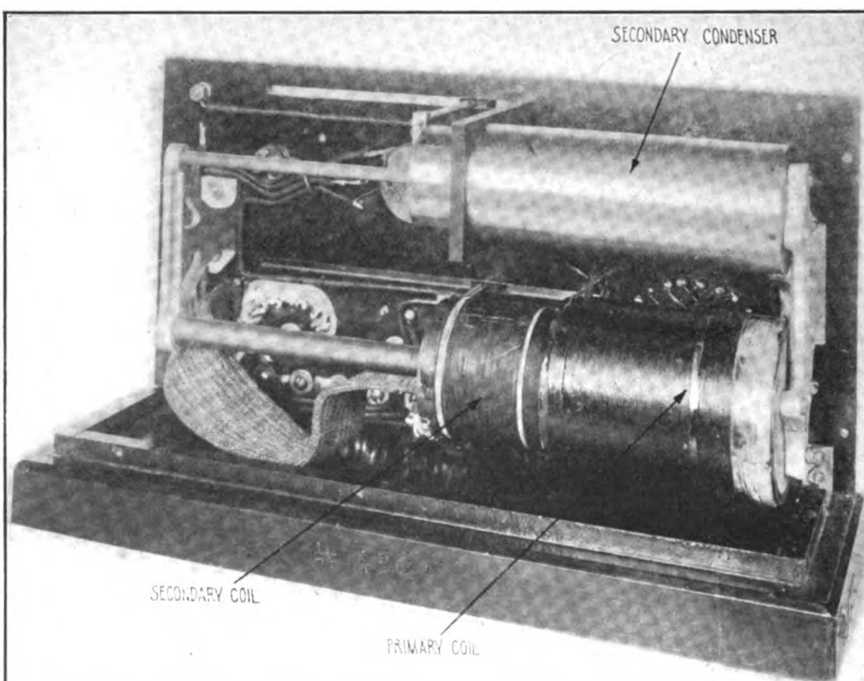


Figure 148—Rear view of the type 112 receiving tuner showing the primary and secondary inductances and the tubular secondary condenser.

Experimenters' World

FIRST PRIZE, TEN DOLLARS

"Howler" Code Practice Apparatus

DESPITE the ban put on the amateur stations by the Government for the duration of the War, code practice is more important to-day than in the past.

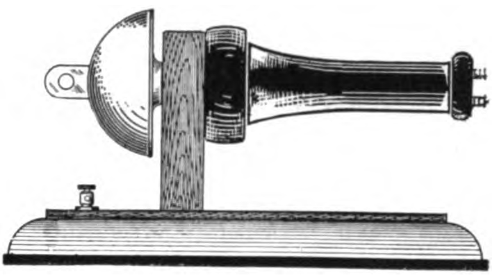


Figure 1—First prize article

Amateur operators who are not serving their country for various very good reasons are depended upon to keep alive the spirit which has aroused universal interest in radiotelegraphy. The writer suggests that the remnants of radio associations that existed before the war still continue to meet and discuss new improvements in radio apparatus, and above all spend a profitable hour in code practice.

To remove the disadvantages of the buzzer type of practice apparatus, a little device is described for producing audio frequency currents of practically constant amplitude for unlimited periods of time. It is unusually simple in construction and can be made from instruments that every "Bug" has on hand.

A glance at the photograph, figure 5, shows it to consist of a telephone transmitter and a telephone receiver mounted on a base facing each other. Constructional details are hardly necessary. Simply a base of any convenient shape or size, a wood upright with a hole cut through it, and the instruments mounted on either side of the upright, are all that is required. Figure 1 shows a side view of the completed instrument employing a single type of receiver.

Everyone is acquainted with the phenomena that takes place when the receiver of a telephone set is held up to the transmitter. A high pitched note results from the interaction of the two instruments. The two instruments are connected in series with a battery of 8 to 12 volts. It is, however, necessary to connect the receiver into the circuit in such a manner that the current from the batteries serves to strengthen and not to weaken the magnetism of the receiver poles.

The resistance of this arrangement is naturally high (in the neighborhood of 90 ohms) hence the current flowing

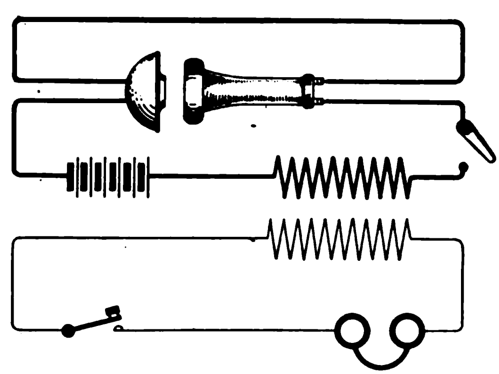


Figure 2—First prize article

is small. A set of three flashlight batteries will operate the device for months. Old dry batteries of no use for any other purpose can be employed also. The note of the instrument and the volume of sound can be varied by altering the voltage.

It is manifestly impractical to connect other apparatus in series with the instrument, or oscillator, as it is pre-

ferably called. Use is made of a standard telephone induction coil, the primary being connected in the oscillator circuit, the secondary in series with a receiver and a key as shown in figure 2. In this case the oscillator is operated constantly, the key being used to open and close the telephone circuit to produce the dots and dashes of the telegraph code. This effectively eliminates the loud click that would be heard were the circuit closed and the key in the battery circuit.

When more than one person desires to practice with the device, additional keys and receivers can be included in the circuit as illustrated in figure 3. With this circuit, the closing of any key will give a signal in all the receivers.

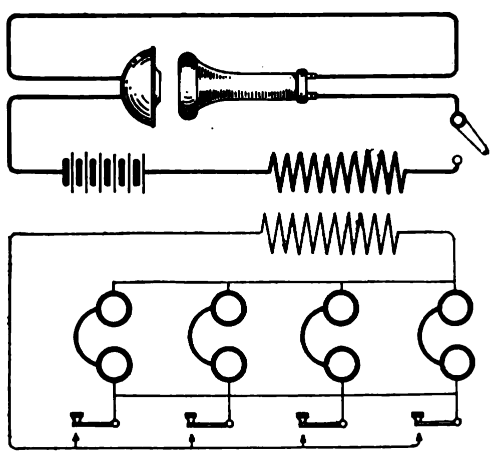


Figure 3—First prize article

We now come to another interesting possibility of the device, namely, the production of interference that is so necessary to good code practice. The only additional instruments required to make this possible are an old loose coupler and another induction coil. The wiring diagram is shown in figure 4.

It will be seen that two practice circuits intercoupled by the loose coupler L, C, are employed. In this manner the amount of interference can be varied by adjusting the coupler so that signals made in one circuit will be heard weakly in the other and thus provide interference. The use of this hook-up requires at least four persons.

From a theoretical standpoint it

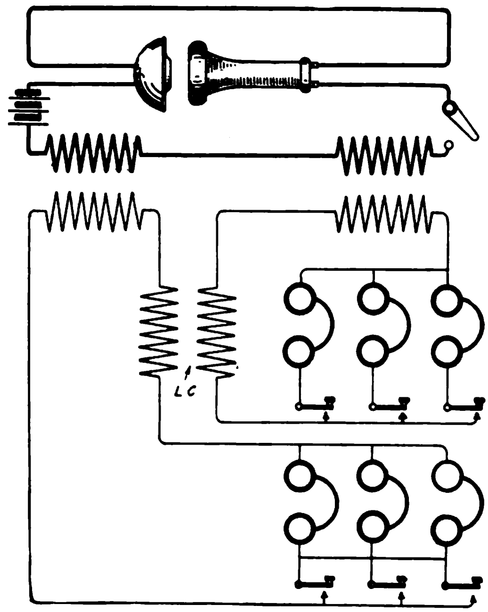


Figure 4—First prize article

might appear that the sound made while the oscillator is in operation would be annoying. As a matter of fact the reverse is true. The instrument made by the writer can hardly be heard at three feet, while it gives a clear high pitched note in the receivers. The latter may be of any resistance. When a large number are employed it might be advisable to use

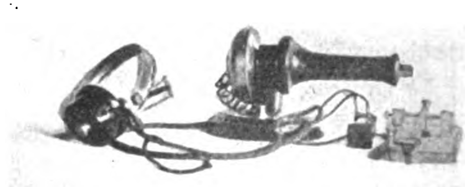


Figure 5—First prize article

1000-ohm telephones, but up to six, 75-ohm telephones will operate satisfactorily. The note emitted is very musical, clear and absolutely constant without stutter or break. In fact, the device provides an ideal source of audio frequency current for code prac-

tice or other requirements in the laboratory.

Thos. W. Benson, *Pennsylvania.*

SECOND PRIZE, FIVE DOLLARS

A Supersensitive Receiving Set

If the Editor of this splendid magazine will allow me the space, I feel confident that I can present in full detail the best possible receiving set that an amateur can construct out of the available apparatus on the market. It should be kept in mind, however, that the construction of wireless apparatus is not permitted while we are at war.

The receiver is designed both for damped and undamped oscillations, and also has a two-step amplifier attachment that will amplify radio signals at least 150 times their original strength. The apparatus is not complicated; anybody who has had experience with undamped receivers can fully comprehend its working. For those lacking experience with the amplifier, I would recommend that they secure a copy of "How to Conduct a Radio Club," wherein its workings are described to perfection.

In figure 1, the general dimensions and construction of the cabinet are given in detail. The dimensions apply to amateurs who cannot erect an aerial in excess of 300 feet in length, and will work equally as well on an aerial of 100 feet in length. The longer the aerial the better the results, but remarkable distances have been covered with a 100-foot aerial in connection with this set.

In figure 2 the dimensions of the coils and coupler are given. The primary of the coupler may be wound on a tube 7 inches in diameter and 12 inches long, with No. 28 single silk. Switch No. 1 covers every ten turns. It has 15 taps. Switch No. 2 cuts in every 1 inch of winding and has ten taps. The secondary is wound with No. 30 single silk, and is tapped off every ½ inch. The twenty-four taps are divided between two 12 point switches, as shown in figure 1.

The coils L and L-1 are each 30

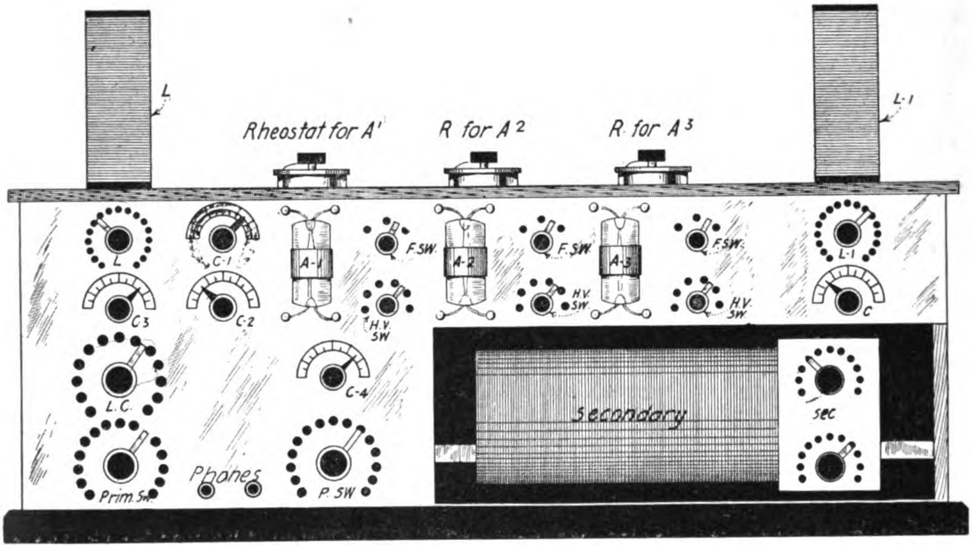


Figure 1—Second prize article

inches long and 4 inches in diameter, wound with No. 30 single silk. They are tapped every 2 inches. A tubular bulb is suitable for continuous wave reception, but good results have been obtained with the old round bulbs.

The coils L-3 and L-4 are obtained from the secondary of a ½ inch spark coil, the primary being removed and the core replaced.

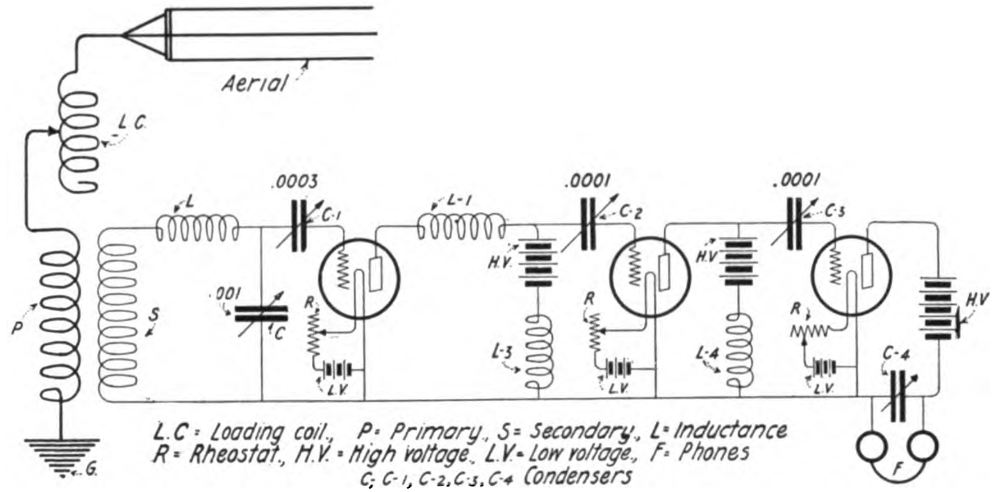


Figure 2—Second prize article

A loading coil may be inserted in series with the primary winding having the following dimensions: 4 inches in diameter and 12 inches long, wound with No. 26 single silk. No enameled wire should be used in a set of this kind, as experiments have proven it unsatisfactory for highly sensitive work.

I would recommend oak for the cabinet. This wood can be secured at nominal cost, and if it is treated with black stain, Johnson's Flemish Oak,

and then rubbed down several times with wax, it fairly resembles hard rubber.

It should be mentioned also that if one does not care to use the amplifiers he should have no trouble in receiving 3,000 miles with this set under favorable conditions. With an aerial but 100 feet in length no difficulty should be experienced in receiving stations as far as 7,000 miles, under favorable conditions.

The wood required for the construction of the cabinet is as follows: The base should be 36 inches in length, 12 inches in width and 3/4 inch in thickness. The same dimensions apply to the top. The front should be 12 inches in height, 34 inches in length and 1/2 inch in thickness; the ends 10 inches wide, 12 inches in height and 1/2 inch in thickness, and the secondary front 4 inches wide, 6 inches in height and 1/4 inch in thickness.

Charles R. Doty, *New York.*

THIRD PRIZE, THREE DOLLARS

The Construction Of An Amateur Telephone Cabinet

SOME time ago I made the telephone cabinet here described for a short telephone line, most of the materials for which can be found in any experimenter's shop. The drawing gives the dimensions of the cabinet except for

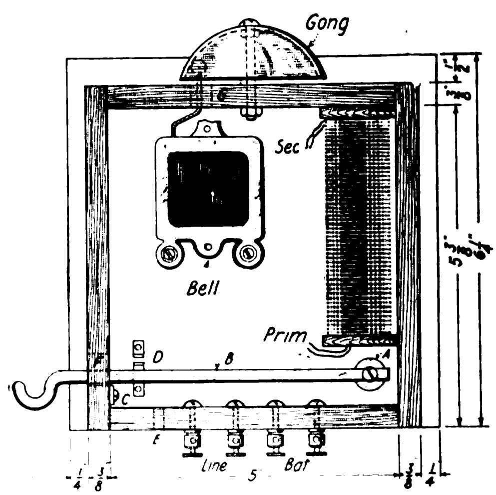


Figure 1—Third prize article

the width of the side pieces. They are each 2 inches wide. The wood for the top piece of the cabinet (figure 2) is of ¼ inch wood. One 2½ inch gong is mounted on the cabinet, as shown, and the clapper arm of the bell passes through a ¼ inch hole G. I used an ordinary door bell and broke off the

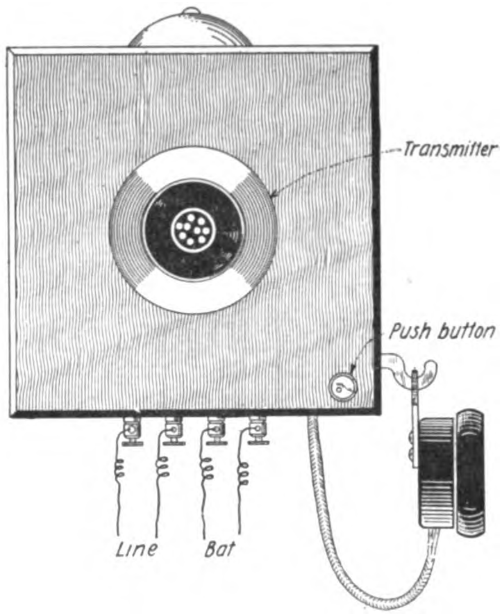


Figure 2—Third prize article

piece which originally supported the gong.

The induction coil is made by covering a small bundle of iron wires with a layer of paper, then winding on two layers of No. 26 S. C. C. wire for the primary. A layer of paper comes next and then four layers of wire for the secondary.

The arm B, figure 1, to support the receiver, is a three-sixteenth inch brass or iron rod, bent as shown and flattened at one end for the threaded hole to take a $^{6}/_{32}$ pivot screw. This is supported by a piece of ½ inch brass rod about 1 inch long; A, which has a hole bored through its length, threaded by a $^{6}/_{32}$ tap. It is held to the back board by a screw and also enters this hole. At the left of the box is a slot F, about ¼ inch wide by ½ inch long, for the lever to play in. Under the slot is a piece of brass, C,

which serves as a stop and also as a contact to cut the telephones and the secondary of the induction coil out of the line circuit when the lever is down.

The function of the automatic switch, D, is to close the circuit to the primary of the induction coil when the lever is up for talking. It is made by fastening two strips of spring brass to the back board so that, when the lever is up, the brass fuses are in contact. The lever must be insulated from the

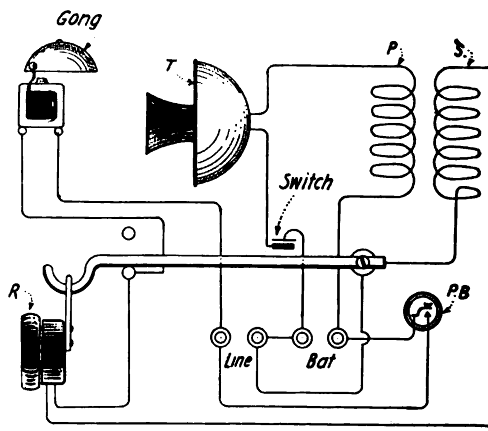


Figure 3—Third prize article

brass strips by tape or some other insulating material.

A ¼-inch hole E is made in the bottom of the box for the receiver cord to pass through. The binding posts are placed about 1 inch apart. A rubber band pulls the lever up when the receiver is removed. A wire spring would prove more satisfactory.

The transmitter and push button are mounted on the front of the cabinet, as in figure 2.

This set is at present being used on a line about 300 feet long. It works perfectly with a 6-volt storage battery. To call, the receiver is lifted from the hook and the button pressed. The buzzing in the receiver when the button is pressed tells if the bell on the other end of the line is working. The connections are shown in figure 3. The connections between the two middle binding posts are a part of the calling circuit.

John B. Moore, *New York.*

The Monthly Service Bulletin of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

"I NOTE in the April number of THE WIRELESS AGE queries department," writes John M. Clayton, Little Rock, Arkansas, "some one asks the greatest distance which has been covered over land by an amateur, and your reply that you think 1,400 miles is the record. For quite a while I have been collecting data of four record stations and the following extract from quite a voluminous amount of information may interest you.

"9ZN at Chicago has worked with a station (7EQ) at Baker City, Oregon, about 1,500 miles. 9ZN worked on 425 meters, and 7EQ on 200. This, I believe, is the record for actual talking. 9ZN has been heard by 6EA at Los Angeles. 9EP at Kansas City,

Missouri has been heard by 6DM at noon several times. 8NH at St. Mary's, Ohio, and 8AEZ at Lima, Ohio, have both been heard by 6DM at Phoenix, Arizona. 2PM has heard 9ZF; 2PM is at New York City and 9ZF is at Denver. 5BB at Franklinton, La., has worked with 9XM at Grand Forks, N. D. 9ABD at Jefferson City, Mo., has been heard on both coasts, as have also 9ZK, 9EP and 9JW.

"I would suggest that those of the amateurs who have been left behind can do great service by voluntarily teaching code work at nights to men eligible to the draft.

"With another amateur in the city, I have been teaching code every night for the past two months to a class of about fifty drafted men at the local Y. M. C. A. Already fourteen of them have successfully passed the radio requirements for the Navy and Marines and have left."

Young oiler in the Naval Reserve force was "over-rated" and was directed to appear before a board and "show cause as to why he should not be busted down so low that he'd have to reach up to touch bottom." (This is a true one.) Examination took place and consisted of the following questions and answers, or rather we should say "answers and questions," for the *answers* rank first, as the questions are not near as good as the answers. ("Let 'er go!");

Q. "What does an oiler do?"

A. "He oils."

Q. "Do you know anything about oiling?"

A. "Nope."

Q. "How came you, then, to be an oiler?"

A. "Met a guy who made me an oiler."

Q. "If you had a boat with an 80-h. p. engine in it and you received orders to get underway, what would you do?"

A. "I'd prime her, crank her and go."

Q. "What if it wouldn't go?"

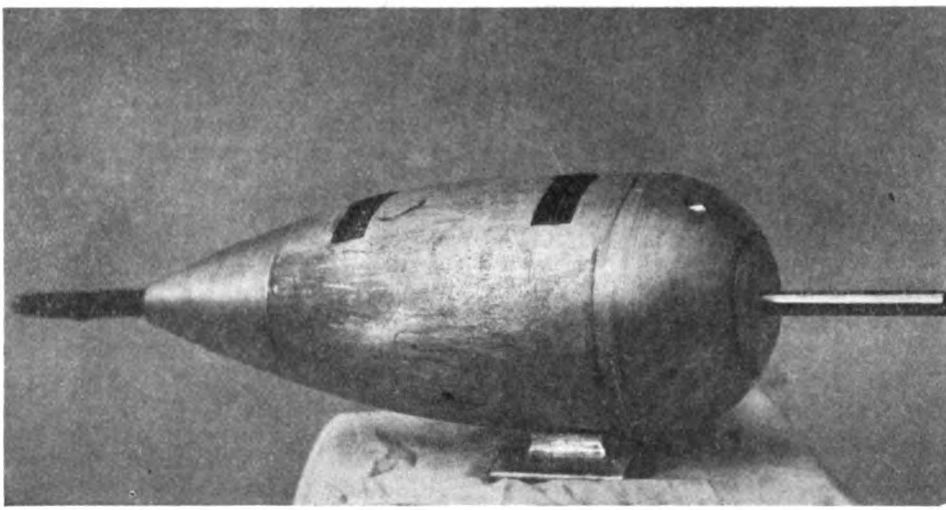
A. "I'd crank her again."

Q. "What if it wouldn't go then?"

A. "Well, this engine I'm thinking about WOULD go."—*Our Navy.*

A Novel Generator for Airplane Wireless

THE accompanying illustration shows a unique electric generator for airplane radio sets, developed by a manufacturer at Stamford, Conn. The dynamo is a combination of two direct current generators mounted in a torpedo-shaped shell. One of the generators delivers low voltage for lighting the filament of the vacuum tube wireless receiver. The other generator supplies 1200 to 1500 volts for wireless transmission. Both armatures are mounted on the same shaft and supported at each end by ball bearings. The outfit is intended to be driven by a small propellor and to be used as energy source for transmitting and receiving wireless telephone messages on aeroplanes in military service.



Airplane wireless generator

The Construction of a One-Inch Spark Coil

THE amateur about to begin his elementary experiments in radio is seldom in a position to purchase an expensive wireless telegraph transmitter. Of course I am aware that the experimenter is not permitted to construct wireless apparatus until after the War, but for beginners who would care to construct a simple one-inch spark coil for transmitting over a distance of a few miles by wireless I submit the general details of construction. It is assumed that the experimenter is familiar with the general design of induction coils. I found that a coil of the dimensions to be described will transmit approximately ten miles and can be constructed at a cost of $2.75.

The materials required are as follows:

1 lb. No. 34 enameled magnet wire.
¼ lb. No. 16 D. C. C. magnet wire.
1 core 8 in. in length by 1 in. in diameter.
2 lbs. paraffine.
1 vibrator for 1 in. coil.
4 binding posts.
1 lb. tinfoil.
2 pieces oak 4 in. by 8 in. by ¼ in.
2 pieces oak 4½ in. by 8½ in. by ¼ in.
2 pieces oak 4 in. by 4 in by ¼ in.

The core is made of a bundle of No. 22 soft iron wire, cut into pieces 8 in. in length. After the wire has been cut it is placed into a 1 in. pipe heated to red heat. After this process has been gone over twice the core should be removed and taped. It is often found that a core can be bought cheaper than it can be made.

The primary wire consists of two layers of No. 16 D. C. C. magnet wire wound around the core. It should be wound with twenty layers of paraffined paper and immersed in melted paraffine.

The secondary winding consists of 1 lb. of No. 34 enameled magnet wire wound in five pies 1 in. in thickness. After each pie has been wound it should be carefully removed and

soaked in melted paraffine. When all the pies have been wound they should be connected so that their E. M. F.'s will not oppose. Paraffine blotting paper should be placed between each pie and the whole coil should be boiled in paraffine for thirty minutes.

The vibrator condenser is made of 80 sheets of tinfoil 7 in. by 3½ in. and 80 sheets of paper 7½ in. by 4 in. These are piled up alternatively. The ends of the tinfoil should project out about 1 in. The condenser also is soaked in melted paraffine.

After the coil is completed it should be assembled in a wooden cabinet. The wood may be of any kind, but oak is preferable.

Six dry cells connected in series should give a one-inch spark.

MAURICE LEE.

Hydrogen Gas As Fuel

HYDROGEN was successfully used as a fuel for an automobile in a test conducted at The Hague, Holland, for the purpose of determining its value as a substitute for existing fuels. The test, conducted by the manager of a large taxicab company and Henri Meyer, editor of the Dutch motor journal, "Het Motorrywiel," of Arnheim, Holland, showed that hydrogen can be used without any of the annoyances and irregularities of operation which might ordinarily be supposed would result, such as misfiring and backfiring. The car used in the test was a Spyker taxicab.

The hydrogen was contained in a steel tank six feet long. This tank held 4600 liters (about 162 cubic feet) compressed to 160 atmospheres, which was sufficient to operate the vehicle for sixteen miles. The gas was fed from the tank through a reduction valve which brought the pressure practically to atmospheric, the feed then being through a three millimeter jet which fed directly into the carbureter mixing chamber. At the start of the test the spark advance was reduced somewhat, but after changes in the mixture were made the spark was carried at full advance without difficulty.

Some of the Good Things in Store for You

In the August issue of THE WIRELESS AGE you will find one of the most interesting articles that has appeared in many months. It will tell about Pan-American Wireless developments.

You will learn about the erection of new Radio Stations now under construction which when completed will promote closer relations between us and our Southern neighbors.

An interesting and instructive article for visual code communication by Lieut. Col. *B. O. Lenoir,* U. S. A., will appear in the August issue. This article should prove of intense interest to all Signal Corps men.

These specials will appear in addition to the regular monthly instruction courses in Aviation, Navigation, Signal Corps work and War Time Wireless.

THE WIRELESS AGE *is on sale after the 15th of each month on the principal newsstands throughout the country at* 20 *cents per copy or mailed to any address for* $2.00 *per year payable in advance.*

A Convenient Telephone

THE accompanying illustration shows a most convenient form of telephone receiver and transmitter. Telephone service is made better and simpler because unnecessary physical exertion is eliminated.

In the early days of the telephone considerable gymnastic efforts, both of muscle and brain, was usually neces-

Convenient telephone

sary for a successful conversation. Each succeeding improvement of the telephone brings the talking parties nearer together in the easiest way.

The stand of this telephone has a heavy, pressed steel cradle, convenient and practical, measuring in height 7 inches and in length 10¼ inches.

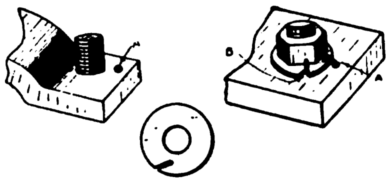
With this telephone equipment, the right or left hand is always free for writing. For instance, when one wishes to telephone from any position, standing, sitting or reclining, he can grasp the 'phone and immediately begin to talk. There is no need of holding a desk telephone in one hand and a receiver in another and no need of balancing a portable telephone on an arm chair and straining one's neck, or of leaning awkwardly over inkwells and papers on the desk in a distracting way, to complete the connection.

The receiver shell, the handle, the transmitter and the mouthpiece are of heavy bakelite, which is indestructible in ordinary telephone service. It is a duplicate of "foreign types" and has been in service in Europe for a number of years, where it takes preference over any other form.

A Simple Lock Nut.

CHARLES H. WILLEY, in a recent issue of the *Electrical Review*, tells us how to make a simple lock nut. He says:

"We were troubled with the nuts loosening up on some of our machinery, due to vibration, or other reasons.



Improvised washer used as a lock nut

As no lock nut could be used, and it was not feasible to pin the nuts, we had to use some sort of locking device. The lock washer shown was used.

"These sketches are quite clear, but it may be well to say that the hole A should be as generous as reasonable for receiving the lip. Any ordinary washer can be used. The lip B is cut in with a hack saw before applying the washer. This is turned up as shown, and with a punch or drift, the lip A is impressed into the hole."

A Full Wave Magnetic Rectifier

THE accompanying illustration shows a full wave magnetic rectifier for charging storage batteries.

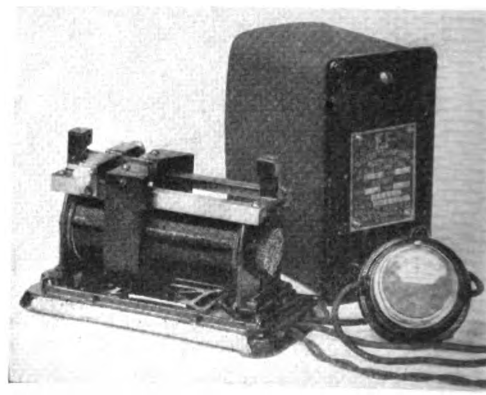
A battery, if not kept fully charged, rapidly deteriorates on account of the hardening of the plates.

It is well known that most light and power current is alternating, and cannot be used to charge batteries. It is the purpose of the rectifier to change alternating current to direct current.

The line voltage is reduced to the proper charging voltage by a special transformer. Both the positive and negative halves of the alternating current wave are rectified into a steady uni-directional charging current which makes the cost of charging so low that the rectifier quickly pays for itself.

This device saves times, money and trouble, and it makes every lamp socket a charging station. It takes only a minute to screw the plug on the end of wire into a lamp socket and

connect the other two wires to the battery. The battery of an automobile can thus be charged in a few hours without removal from the car—and at no more expense than in burning a 100-watt lamp for the same length of time. A complete charge for the average starting and lighting battery costs about 6 cents, which is at the rate of ½ cent an hour to operate.



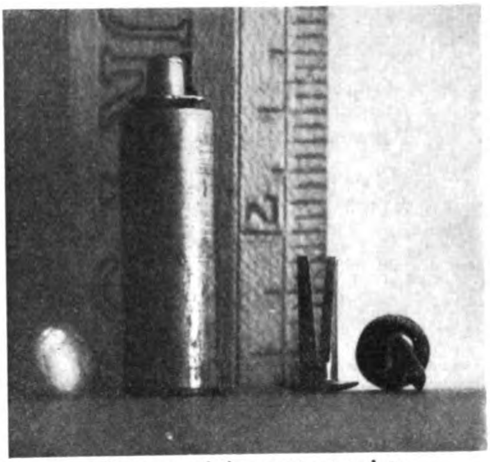
Magnetic wave rectifier

The charge starts at a high rate, from 10 to 15 amperes, bringing the temperature of the battery up to normal working condition. This reduces the time required for charging, and as the charge nears completion the rate gradually reduces itself owing to the rise of the battery E. M. F. This results in what is known as the "Tapered charge." The "Tapered charge" is impossible with any charging means which operates at a fixed low rate, but is automatically taken care of by the rectifier.

It is of interest to note that the rectifier is self-starting and not affected by line failures. If the line current is turned off the battery cannot discharge through the rectifier. When the current is turned on the rectifier starts itself; thus night charging is safe and saves time. One form of this device measuring 5 by 7 by 9 inches and having a weight of 14 pounds will charge a 6-volt battery or two or more 6-volt batteries connected in multiple at an average rate of 10 to 15 amperes. It will fully charge the average starting and lighting automobile battery over night.

An Economical Contact Point

PRACTICALLY every experimenter has a desire to lessen the strain on the pocket-book. One of the obstacles to the fulfillment of this desire rests in the construction of any electrical or radio apparatus using contact points. The present cost of such points runs from two cents for midget points to six cents and more for large sized points. This cost is the basis for the



Rivets used for contact points

use of cartridge shells, which, however, have the disadvantge of presenting neither a good surface for soldering leads nor a means of keeping them from falling out of switch panels. A still better point than that obtained from a cartridge shell, and one that is not generally known is the brass rivet (used in Ford magnetos) which can be obtained at any licensed Ford Service Station at a cost of five cents per dozen. The photograph shows several of the rivets one-half inch in length, having five-sixteenths inch heads and five-thirty-second inch shanks. They should be placed in five-thirty-second inch holes spaced at least three-eighths inch between centers. The points are placed in the holes and the lips of the shank spread by hammering either upon a large spike placed with its point between the lips or upon a special tool such as shown in the illustration. The leads are then most conveniently soldered to the interior of the lips. Ford rivets have another advantage in the fact that they may be used on

any material over 1/16 of an inch thick and will remain in adjustment.

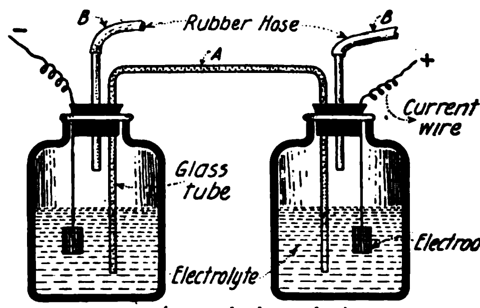
Alan C. Rockwood.

Electrolysis Apparatus.

THE object of this apparatus is to collect the products of the electrolysis separately and without any mixing.

The materials required are: Two bottles and two hole stoppers, glass tubing and electrodes.

The electrolyte fills the tube A when air is blown in through one of the



A novel electrolysis apparatus

tubes B, and electric communication established. The wires holding the electrodes are held between the bottle neck and the stopper.

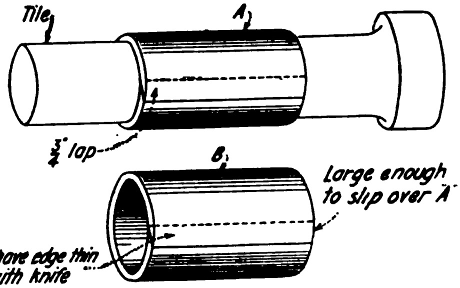
The rate of current flow can be lessened by partly closing one of the delivery tubes B, the pressure forcing the liquid out and diminishing the surface of contact of the electrode. The gases evolved (if any) can be obtained at any pressure by closing the rubber tubes with stop clamps.

Henry Klaus.

A Method of Making Cardboard Tubes For Tuning Coils

THE preliminary step in the construction of card-board tubes is to secure a piece of tile or something circular of the correct dimensions and wind it with pasteboard, as shown in the accompanying drawing. It is important to get it the right length and wide enough to insure a three-quarter inch lap. The edges are next shaved down with a knife (so that there will be no hump) and glued. Another piece of pasteboard is made in the same way to fit rather loosely over the one on the

tile. It is then slipped off and a paste of flour and water smeared on the inside of the tube. The larger one must be slipped on immediately as the paste



Method of constructing cardboard tubes for tuning coils

causes the tube to expand. After standing a few hours the tubes contract again and fit snugly about the form. They may now be immersed in melted paraffine and finally covered with shellac. These are as solid as the ones which are purchased. I have used them for loose couplers and coils of various sorts.

HENRY KLAUS.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

M. F. B., Sunbury-on-Thames, Middlesex, Eng., inquires:

Ques.—(1) With a simple regenerative three-element vacuum bulb circuit (single bulb) such as described on page 124 of "How to Conduct a Radio Club" would it be possible to receive Arlington time signals at a range of 3,000 miles across open sea and with a ship's aerial 250 feet long and 125 feet high?

Ans.—(1) Signals should be received at a distance of 3,000 miles at night time provided the regenerative coupler is carefully constructed and the correct polarity obtained between the primary and secondary winding of the regenerative transformer.

Ques.—(2) What is the relative ratio of audibility between the three-element vacuum bulb and the crystal detector?

Ans.—(2) As a regenerative system the tube will give amplifications up to at least

100 to 150 times as compared to a simple crystal rectifier. For weak signals, the amplification factor is considerably in excess of this.

* * *

H. P. M., Royse City, Texas:

We do not fully understand your query No. 1. Do you desire to know if automatic senders are employed in wireless telegraphy? If so, it may be said that they have been used to some extent in trans-Atlantic experimental work and in commercial work. It is contemplated to employ automatic transmitters exclusively in the near future. The most favored form of automatic transmitter is the Wheatstone, the signals being first perforated on tape and fed through the machine at speeds up to 100 words per minute.

It is impossible for us to trace down the stations from which you heard signals in pre-War times.

The aerial you describe had a natural wave length of approximately 160 meters. We presume that this aerial has been taken down in accordance with Government orders.

* * *

G. G. S., Fitchburg, Mass.:

We have carefully scrutinized your diagram of connections for charging storage cells and were unable to ascertain why your carbon lamps should burn out, in view of the fact that you have two 110-volt lamps connected in series to 220 volt mains. Perhaps the potential of the line at times exceeds 220 volts. There is nothing in the diagram to indicate why these lamps burn out, because in the particular circuit you have shown the amount of current flowing is governed by the lamps and not by the storage cells. The fact that the generator is cut off, leaving the motors connected to the line, would have nothing to do with the burning out of the lamps, because the voltage of the storage cells is insufficient in this circuit to light the lamps to even partial brilliancy. We have no suggestions to offer.

* * *

V. E. E., Pennsgrove, N. J.:

Ques.—(1) If the area of metallic coatings of a condenser be doubled and the thickness of the dielectric halved, how will its capacity be affected?

Ans.—(1) It will be increased by 4.

Ques.—(2) Will you oblige me by explaining why its capacity will be thus affected, in the answer given to No. 1?

Ans.—(2) This can be determined from the formula:

$$C=0.0885\ K\ \frac{S}{T}\ \text{microfarads}$$

where S=the surface area of one plate
T=thickness of the dielectric.

It is self-evident that if S is doubled, and T is reduced one-half, the capacity will be increased four times.

A. B., New Orleans, La.:

Like your co-worker, A. L. D., you will have to readjust yourself to the new conditions encountered in the working of modern wireless telegraph apparatus. Practically all modern sets are fitted with wavelength changing switches, whereby the transmitting operator can make an instant change merely by throwing the handle of the switch.

The computation you desire on the calculations of the natural wave length of an aerial from its dimensions is laborious. A good explanation of Professor Howe's formula appears in the book entitled "The Calculation and Measurement of Inductance and Capacity," by W. H. Nottage, copies of which can be purchased from Wireless Press, Inc., 25 Elm street, New York City.

We are unable to give you details of the airplane apparatus you mention. War safety measures forbid us to speak on this point. After the war, complete descriptions of the apparatus such as is being employed in the Army and Navy will be available. We have no exact data on the range of airplane transmitting apparatus, nor have the reports of tests made by the Government been made public; but you can rest assured that the equipment is operative and that some remarkable results in communication have been obtained.

A comprehensive statement of the subject mentioned in your last query will shortly be published by the Wireless Press. Details will appear later in the advertising columns.

John Hays Hammond's radio control apparatus for torpedoes is fully described in a recent patent issued by the U. S. Patent Office. The circuits are too complicated to be gone over in detail in these columns. The subject is also treated in "Radio-dynamics" by Benjamin Meissner, copies of which can be purchased from Wireless Press, Inc., 25 Elm street, New York City.

The construction of a decremeter applicable to amateur needs is fully covered in the book, "How to Conduct a Radio Club."

A Hint for the Amateur Workshop

If you wish to measure a circular rod and have no calipers, use a monkey wrench and then measure the distance between the jaws. You can use this in the same way as you would a micrometer, but of course it will not be so accurate.

If you are in need of a chisel and have none, grind the teeth off of a flat file and grind an edge on it. This will make an excellent chisel. I speak from experience.

Erwin F. Gray.

August, 1918

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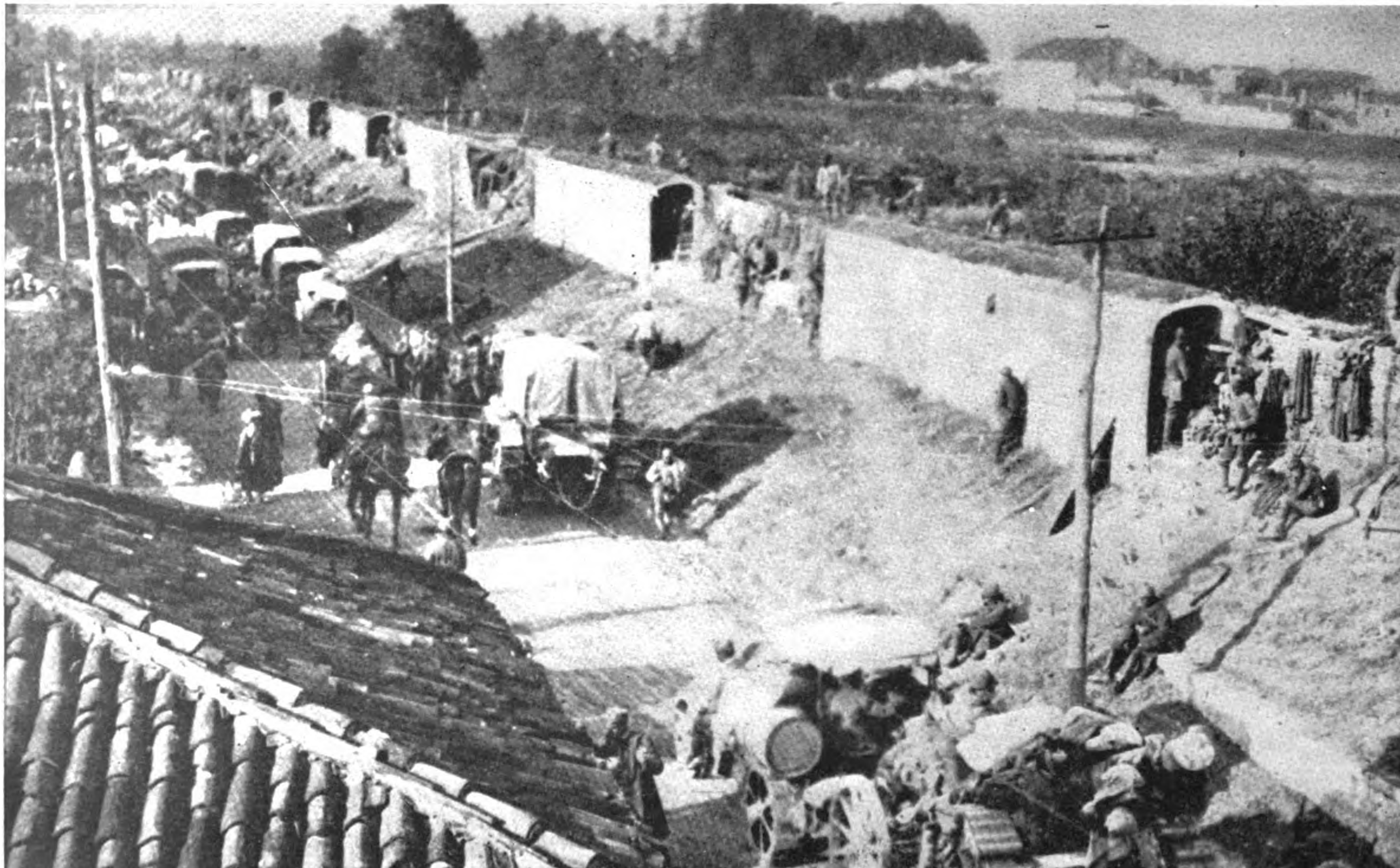


Official Italian Photo

In some instances Italian trenches are very different from those on the Western Front, as this photograph discloses; the earthworks are built above ground and then covered over, troops living in the fortified sections

THE WIRELESS AGE

WORLD WIDE WIRELESS

Unmanned Airplane to Be Under Wireless Control

FROM San Diego, Calif., comes a most interesting story of an airplane to be operated by wireless from the ground and to contain freight or bombs but neither pilot nor observer. That the device is not a myth is vouched for by the inventor, Flight Instructor Robbins of the Rockwell Field Aviation School, who hopes soon to demonstrate the practical usefulness of the mechanism. In fact, the inventor claims to have already demonstrated, to his own satisfaction, the practicality of the dual controls, which were placed 12 miles apart and operated perfectly by means of wireless.

If workable in a practical way it would appear that this unarmed craft might be of tremendous value in a definite and restricted line of service. At any rate, it presents a fascinating development of wireless control which ought to add materially to the human understanding of the mastery of the air.

Hun Uses His Wireless to Spread Lies About Americans

THE German wireless, which early in May sent out a despatch alleging that American aviators were crossing to Europe on hospital ships, later reiterated these charges in a longer despatch. The reason for the emphasis placed on this false charge by the Germans, it is pointed out, is probably that they are laying the foundation for justification at a later date of the torpedoing of American hospital ships in case any such ships are put into the transatlantic service to carry home invalided soldiers. Similar charges were spread about British hospital ships as a prelude to torpedoing them. The German wireless message in part said:

"American aviators are crossing to Europe as members of the Red Cross on hospital ships.

"Prisoners openly admit that it is the general practice for aviators to enter the American ambulance service for their passage to Europe and to cross on hospital ships. After they are landed in France they immediately transfer to the Automobile Corps and thence into the air service."

The British Admiralty denied the charge that American aviators were crossing on hospital ships.

Two weeks later, a German wireless message saying that grave insubordination is a daily occurrence in American army training camps was made public by the State Department as an illustration of the lengths to which the German government is going in an effort to keep up the spirits of the civil population.

The message, which was sent out May 9, and which was given out by the State Department without comment, said:

"According to information from Christiania, Norwegians recently arrived from America say that grave cases of insubordination occur daily in American training camps. At first breaches of discipline were punished by death, but this was stopped owing to the number of cases. In a particularly flagrant instance all the soldiers in a camp acted collectively and obtained not only

immunity for the mutineers but punishment for all officers. Furthermore, much damage to works and material is being done."

German wireless messages are sent out for circulation in neutral countries and for the information of German diplomatic representatives abroad. Officials have no doubt that the foregoing statement was given general circulation throughout Germany, as well as in Austria-Hungary.

An Inland Tribute to Patriotic Operators

IF there is any truth in the axiom that the inland man loves the sea most, it may have served as the inspiration for a recent editorial of appreciation which appeared in the Omaha (Neb.) World Herald. The substance of the eulogy follows:

A group of patriots of which very little is said are the Marconi wireless operators. They have a headquarters in the center of the financial district in New York. In those small rooms there are always a number of men waiting for orders. A ship in port never orders a wireless operator until all her cargo and passengers are aboard, and within one hour that operator must be aboard prepared for a voyage through mine fields and zones infested by submarines which will require in most cases weeks of absence. These operators are of all nationalities that are engaged in ocean commerce. They are English, French, Spanish, Italian and from Denmark, Sweden, Norway, Russia, Japan, China, Greece, Holland, Canada, Australia, New Zealand, and all of the South American countries. They receive $80 a month, board and lodging. When they get together it is said that while they speak different languages, each that of his native land, and some of them two or three more, they always seem to understand each other. When they leave the headquarters they have no idea where they are going, but they start on the instant.

Their work is humanitarian, and indirectly they aid the saving hundreds of human lives. Vessels in distress everywhere are aided by them whether they have been torpedoed, overcome by storms or broken machinery. Warnings are sent, calls for help when their own ships are in trouble and many of them have stuck to their posts while their ships were going down until the last man was in the life boats.

Suspected Spy Stations Raided in Chicago

TWO secret wireless stations, one a powerful affair for sending, located on top of a large office building inside the Chicago loop district, were recently raided by operatives from the department of justice. The second was equipped for receiving only and was on the north side.

Investigation has revealed that the "sending" station was powerful enough to transmit messages to Mexico. One man connected with the work, when taken into custody, was found to be registered as an alien enemy.

Two wireless operators were attached to the sending station when Government men raided the office installed on top of the downtown office block. They admitted they had been sending messages for some time, but declared they had no idea where they were sending them.

They insisted they had merely been employed to send and they knew nothing more than this about the affair. They had a knowledge that the stuff they were handling had something to do with Great Lakes, they said. The sending station was rigged up with wires which ran out onto the roof of the skyscraper and were attached to the metal frame of the building to make the necessary "ground."

The receiving station was cleverly concealed in a room on the upper floor of a flat building. Several hundred feet of wire had been rigged up in the room, running back and forth to make the aerial.

Hun Attempt to Destroy Liberian Wireless Plant

FOR the first time since the little African Republic of Liberia declared war on Germany, on Aug. 4, 1917, she has just tasted of the Teuton's wrath.

A German submarine of the largest sea-going type appeared in the port of Monrovia, the capital of Liberia, on the west coast of Africa on April 10, and bombarded the wireless and cable stations there, the State Department at Washington has been informed in an official despatch.

The submarine threw scores of shells from her deck guns into the wireless station, causing extensive damage. She had just turned her attention to the cable office when a steamer was sighted passing the harbor mouth. The submarine left in chase and did not return.

Robert C. Bundy, in charge of the American Legation at Monrovia, sent the news. The first message he sent indicated his belief that the submarine would have no difficulty in destroying all means of communication with the outside world. A later message told of the sudden departure of the U-boat.

Attempt Made to Blow Up Fort Bliss Station

FOUR sticks of dynamite, thirty feet of coiled copper wire and detonating caps were discovered buried under the base of the steel wireless tower at Fort Bliss.

The Fort Bliss wireless station is known as the "motor station" for the Mexican border, between San Antonio and Los Angeles. It receives messages from the wireless station at Southern department headquarters at Fort Sam Houston, and relays them to the smaller stations along the Mexican border. It is said to be the most powerful station on the border.

Substantial Wireless Progress in Australia

WIRELESS conditions in Australasia were interestingly outlined at the Semi-annual meeting of Amalgamated Wireless, Ltd., held at Sydney this year.

The figures in the balance sheet show that the half-year's operations have been satisfactory, and the net profit shows an improvement over the immediately previous half year. The Directors recommended payment of an interim dividend at the usual rate of 5 per cent. per annum. The total reserves have increased since June, 1917, by £2,700 to something over £23,300.

Reference is made in the report to the absence of all revenue from Public Radio-telegrams. This revenue was reasonably anticipated when the company's maritime business was inaugurated, but the war conditions have been responsible for its disappearance. Recovery in that direction will not be possible until shipping affairs reach a settled condition after the war.

Extension in manufacturing and general trading has been very marked, however, during the past twelve months. The demand for wireless apparatus continues, and keeps pace with increased capacity. It is estimated that the number of vessels using wireless service steadily increases, and orders are in hand to equip nearly 20 vessels during the coming year.

Announcement is made of the arrangement with the Wireless Press, Ltd., of London, and the Wireless Press, Inc., of New York, to establish a branch of the Wireless Press in Australia. The main objects of the Wireless Press are to conduct certain news services with the aid of wireless telegraphy, and to issue publications dealing with wireless and allied subjects. Arrangements have already been completed for the Wireless Press, Sydney, to issue a monthly magazine in which a special feature will be made of up-to-date information, and clearly written articles upon the fascinating subject of wireless telegraphy. The magazine will be entitled "Sea, Land and Air."

The company has over 200 persons in its employ, a large majority of whom are Australian born. All employees work in close co-operation and friendship with the management, and fully realize the importance of the work in relation to the war. The seagoing staff exceeds 100 men. A great number of these are frequently employed in the danger zone.

When the Florizel Struck Horn Reef

Story of the Operator on the Newfoundland Steamship—Survivors Owe Their Lives to the Shelter of the Wireless Room, in Which They Spent Two Tragic Nights

By Cecil S. Carter
Marconi Operator

Cecil S. Carter, senior operator aboard the Florizel when she struck Horn Reef on the coast of Newfoundland

I HAVE no doubt many of my fellow operators remember the steamship Florizel as the vessel on which wireless was tested in the ice fields of the North, in its application to the sealing industry. Owned by Messrs. Bowrings, of New York, she was built as an ice breaker and was specially designed for the route that was hers, namely between New York and Newfoundland. This was the run the Florizel had been doing until she met with her fate, which, while not at the hands of the Germans, was perhaps a still more ghastly end, since it involved a loss of ninety-four lives, for she was carrying passengers at the time.

It was at 8 P. M., February 23d, and on a fairly decent night, when the Florizel started on what was to be her last voyage. I took the first trick, while Murphy, my assistant, piped down. All went well during my watch, and when Murphy relieved me at 2 A. M., we were well away from St. John's. After a bit of a talk with Murphy, I slipped off to turn in below, little dreaming how rudely I was to be awakened.

Sleep somehow did not come to me quickly that night, but finally I dozed off into a light slumber. Suddenly I was electrified into consciousness by experiencing the sensation of an awful bump, and this was immediately followed by another and still harder one. The pony wire that was connected to the wireless cabin then started to sing "S O S, S O S, Get up quickly!" And you can believe that I did get a move on in short order. First jamming an O. K. back to Murphy, I jumped into my uniform, pulled on an overcoat and made posthaste for the wireless room. A huge sea met me with staggering force when I reached the deck, but luck was with me, and I managed somehow, by groping my way forward, to reach my destination.

On entering the radio room I found that Murphy had just started the generator going. Instructing him to try to get a position from the Captain, I began to send out the S O S. All the time I was thus employed, I was being thrown violently from side to side in the cabin. I must admit that at other times I have been more comfortably situated while sending emergency calls. Soon Murphy came back and gave me "near Cape Race" as a position. I added this information, with the words "fast going to pieces," to the S O S.

The first signals were sent at 4:45 A. M. on power. After one heavy sea the lights went out and then I reverted to the auxiliary set and utilized it for a period of about five minutes. Then came one tremendous smash as a heavy comber struck the cabin, swamped my storage cells and put the

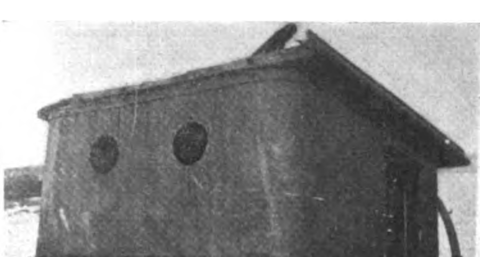
whole set out of commission. A few seconds later Murphy called to me that the topmasts and aerial were down, and I rushed out of the wireless room into the face of a vicious and spiteful comber. It completely swamped the decks and smashed our boats over the side in a moment, and away they flew. There came a yell from somewhere for everybody to hold on fast. A few of us clung to the lee rail by the wireless room, and a Turkish bath was not in it with the drenching we went through.

Shortly after this—it might have been a half hour at that—one of our group suggested getting into the wireless cabin, seeing that it had withstood so much battering. It appeared reasonable to believe that it would keep together for a while longer, so we all worked our way into the steel house. Three others had hastened there before us. By degrees stragglers came in and the room filled up rapidly. One of the last comers brought us the intelligence that the bridge had gone and also the Captain's room, and then another arrival informed us that the smoking room had been swept away. Later information proved these assertions to have been correct, and to our grief we learned that in these accidents fifty souls had been swept into eternity.

Meanwhile things began to quiet down a bit, and we in the cabin had an opportunity to consider our surroundings. There we were, about forty of us, in a compartment eight feet square, all of us wet and sodden, many half-clothed, the radio room leaking through the roof and the seas flooding us at short intervals. Some of the members of our party had suffered broken limbs, and our third mate had his face fearfully bruised, but there were no groans or complaints to be heard. All realized that we must wait and trust for the best to happen. Hour after hour passed. Fortunately daylight was not far away, seeing that we had struck Horn Reef off Broad Cove at 4.45 A. M., Sunday, February 24th.

The coming daylight gave us a bit of cheer, but the seas continued to pound fiercely against our little refuge. But the walls of the wireless cabin held out bravely, and on the pounding somewhat abating, we could get a glimpse through the portholes of people grouped on the shore but evidently helpless to bring aid to us. One little boat which had been spared by the combers tried to put over, but capsized, so that attempt to reach shore had to be abandoned. The dreary hours crawled slowly on, but towards evening our spirits were again cheered by the sight of a couple of small steamers on the horizon.

But unfortunately, the evening drew in quickly and darkness settled down, and we were disappointed to observe the craft drawing off for the night. As I learned afterward, the men on the steamers thought there were only four persons left alive aboard the Florizel. It also came to my knowledge afterward that my S O S was received by Cape Race and by the Pearl, a Government steamer, which latter ship managed to have the message telephoned to the owners' agents in St. John's, where the news of the disaster was received approximately at 5:54 A. M., on Sunday. We ourselves had received no signals, owing probably to the shortness of the time between



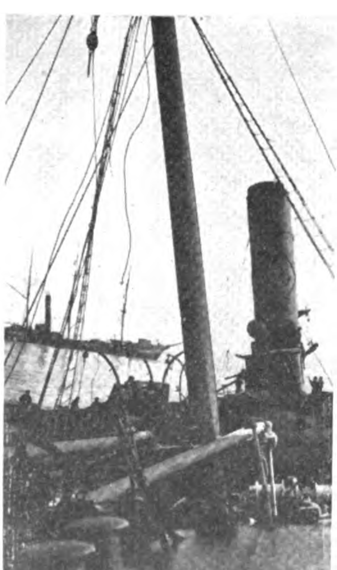
Exterior and interior view of wireless room, size 7x8 feet—34 lives were saved through the protection afforded by this steel structure

the striking of the reef by the Florizel and the flooding of the wireless room by the combers which put the apparatus out of commission. Indeed, I tried once to receive, but apparently the steamers that were attempting to transmit to me had their signals crossed. At that my attempt at receiving lasted only a few seconds, and the approximate time the set was used consumed in all ten minutes.

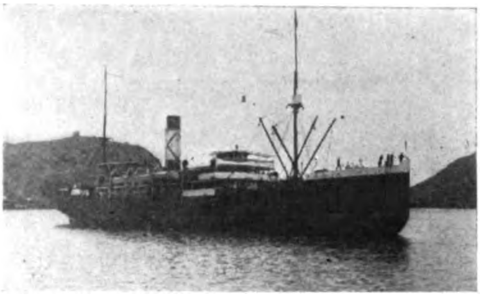
Meanwhile we were packed in the cabin, compelled to keep another night's vigil, the discomforts, if not perils of our situation becoming more aggravated as the hours passed. We were beginning to suffer severely the pangs of hunger and thirst, especially the latter, for no water was available. The men were able to solace themselves a bit with a small portion of tobacco, but even this small comfort was denied two women who were in the cabin, whose pluck and powers of endurance compelled the admiration of all the rest of us. It seems even now inconceivable how these two poor women survived the ordeal of that second night, clad in night dresses, over which they had flung thin jackets, just as they had run from their cabins when the Florizel struck. Their light clothing gave them small protection in the small room from which the door was gone, a sea having wrenched this small protection from its hinges during the morning hours. Still we kept huddled in the room, waiting for rescue, packed so closely that we were unable most of the time to move our arms.

On Sunday afternoon one poor fellow gave up, and we were compelled to lay his body outside on the deck. This was done gently and reverently, and shortly afterward he was carried from sight by a sea. This poor chap was a returned soldier and had lost his wife and child earlier in the day. The time dragged on, and in the attempt to cheer ourselves up a bit we began to sing "Nearer, My God, to Thee" and also "John Brown's Body." The singing tended to raise our spirits somewhat, although our voices sounded verv tremulous and pathetic in the stillness of the night. Others of our party then began to lift their voices in "The Rosary," which obtained a good response. In this fashion the greater part of the night passed away.

Toward two o'clock on Monday morning we sighted a well-lighted ship, and one or two of us having torches in our possession, we at once began to make attempts to communicate with this vessel and several other rescue ships which came into view now and then. In this our efforts were success-



Views of wrecked Florizel. Left—Bow looking aft. Note inner stack jammed up. Center—On Horn Reef breakers on calm day. Right—Crushed side and music room looking forward



Steamship Florizel as she appeared before and after the wreck

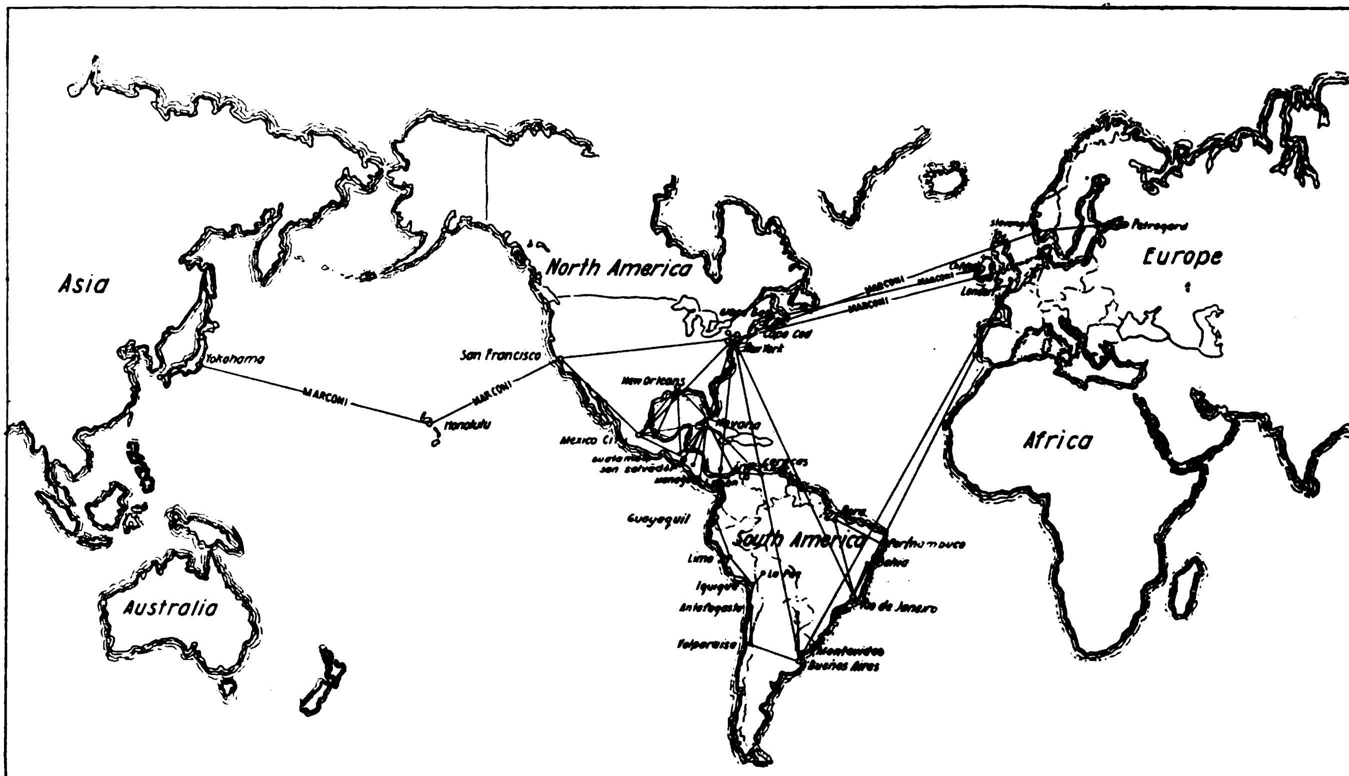
ful, and we then learned that the persons on board the ships were surprised to hear of the number of refugees who were crowded in our small cabin. They informed us that they had attempted to get a boat off to us, but that it had capsized. They added that they would make every effort to succeed in rescuing us in the morning or at least by daybreak. After I had interchanged a few more messages with the ships, I shut the porthole. I had been signaling through this porthole with the torch. When I told the news to my fellow sufferers, they appeared greatly relieved and even cheered.

With the break of day the work of rescue was begun, and I can assure you that it was no easy matter in that rough and tumultuous sea. But the men in charge of the boats were brave and enterprising fellows. They anchored a jolly boat a few yards from the Florizel and thence passed a line to a position near the wireless house, so that the small dories which now approached could maintain their positions in the turbulent waters. Our survivors on board the Florizel were compelled to make a jump for it, and if they landed in the dories they were considered lucky. Those who missed their footing received a cold plunge.

However, once we were finally gathered on board the rescue ships, we obtained the life necessities and the creature comforts from lack of which we had undergone such suffering. We were placed in warm blankets and fed, and the injured members of our party received at least emergency treatment and attentions. We arrived in St. John's again about five hours later, where a great crowd of friends eager to assist us were gathered on the pier. Ambulances and doctors were immediately told off to attend to the survivors and take the wounded to the hospital, while many were cared for by private friends, and members of the crew in some cases, going to the Institute for Seamen.

In all ninety-four persons lost their lives in the Florizel disaster, that number including one of the leading members of the shipping company to which the liner belonged. Among the lost were several prominent residents of St. John's and also an American citizen. A total of forty-two persons were saved, of which thirty-seven owe their lives to the staunch little wireless room in which they had taken refuge on board the wrecked steamship. Amongst the officers who were lost was the chief engineer and the second mate, the latter an old man of sixty-seven years, but yet very bright and spruce. Both of these men had been in the service of the steamship company for more than thirteen years and were well liked and widely known.

The wrecking of the Florizel is an experience such as few of those who survived the catastrophe can ever forget. It was an odd coincidence that my wife was on board the Florizel's sister ship, the Stephano, when the latter was torpedoed off Nantucket a couple of years ago. This was the time when five other ships were sunk by the U-53. I may add that both ships proved themselves game to the last, owing chiefly to their having been so strongly built.



The projected Pan-American Wireless Chain showing how it is to be linked up with all Continents

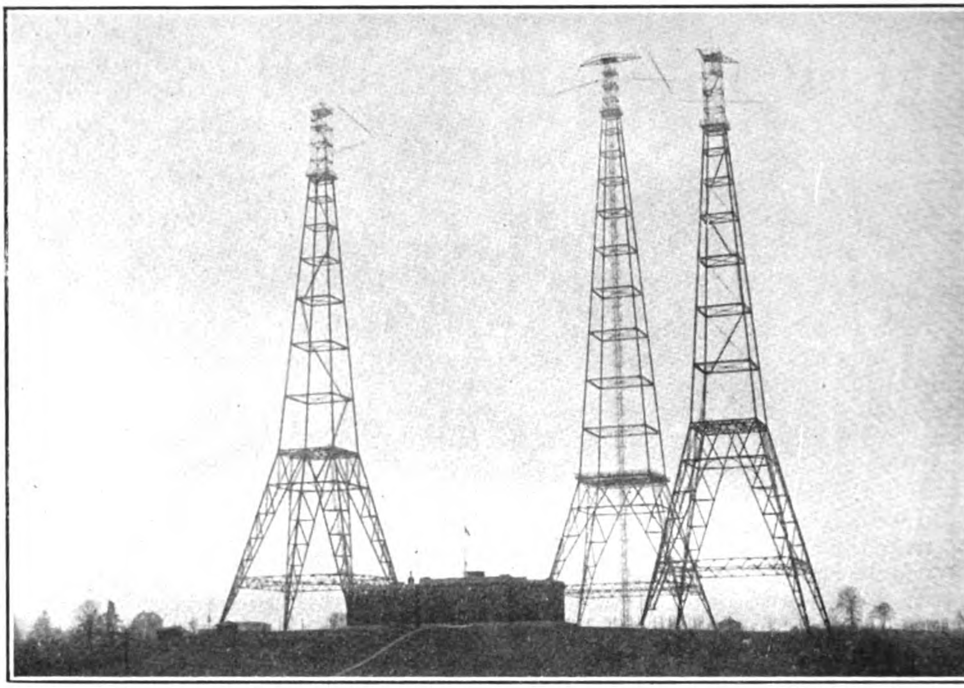
The Pan-American Wireless Chain

The First Practical Step Towards Linking Up the Americas by a Direct System of Wireless Telegraphy

THE recent announcement that the largest wireless station in the world is to be erected near Buenos Aires, heralds the advent of a revolutionary step in communication with South America. It is stated that 11,000 kw. power will be utilized in the new station and the aerials will be suspended from three towers equal in size to the famous Eiffel Tower. Pan-Americanism being based upon the principles of common interest, the Pan-American Wireless Telegraph and Telephone Company, which is to undertake the construction, thus signalizes the most practical step yet taken to develop and extend the trade and general relations of all the countries of the Americas. To convey an adequate idea of the importance and value of this enterprise, it is necessary to describe its objects and to indicate, in some measure, the enormous advantages that will necessarily follow their attainment.

The main purpose of the Pan-American Company is to connect the United States with the whole of South America by means of wireless communication. It will begin with Argentina, Brazil and Uruguay and continue to Chile, Peru and Ecuador, in the order named, arrangements also being made to include Mexico and Cuba contemporaneously with the work in Brazil. In the United States the system will connect with the Western Union land lines, this being in direct connection with over 25,000 telegraph stations. The South American wireless system will connect at New York with trans-Atlantic wireless to Great Britain, Scandinavia and Russia; and at San Francisco with the Hawaiian Islands and thence with the Orient. Arrangements will also be made with the different governments for an exchange of messages over the government telegraph lines, with official authority to the company to maintain its own main offices in the larger cities. It is likewise contemplated to erect stations in the Central American Republics. The fulfillment of this comprehensive program will be greatly facilitated by the adoption of the latest inventions in wireless telegraphy, including the rights and patents of the American and English Marconi Companies and of the Danish Poulsen-Pedersen system. These, in brief, constitute the immediate plans of the new company, whose president is Edward J. Nally, vice-president and general manager of the Marconi Wireless Telegraph Company of America, who had a large share in establishing wireless communication between the United States and Japan by way of the Hawaiian Islands and in building the system that placed the Pacific Coast stations in direct communication with Alaska.

There have been many existing physical obstacles to a proper development of the inter-American commerce, and not the least important of these hindrances to closer trade intercourse amongst the various Republics is the lack of a cheap and rapid system of telegraphic communication. The need for additions to the services operating on the American continent has long been felt by big business. Difficulties resulting from the absence of this important adjunct of commerce were authoritatively expressed during the sessions of the Pan-American Financial Conference held at Washington in May, 1915. At that Conference, which was attended by the President of the United States and members of his cabinet, as well as by the most influen-



It is understood that the lofty towers from which the aerials will be swung in the South American station will be of the self-supporting type, somewhat similar to the Arlington towers here illustrated

tial representatives of all the American governments, there was hardly a speech or a report of an individual or group which did not contain some reference to the urgent necessity for improved telegraphic service between the two Americas. In the official letter addressed by the Secretary of the Treasury to the foreign delegates, on the work of the conference, the following question occupied a prominent place:

"What difficulties exist in the way of direct cable communication between your country and the United States? Give comparison of cable rates between your chief city and New York City, London, Berlin, Paris and Rome."

All the group reports contained the unanimous recommendation of the Conference that the rates of American companies should be on a par with European rates and that each government should seek to have installed a wireless system from country to country; and in the important address delivered by Secretary of Commerce Redfield, the question of telegraphic rates and service was featured as one of the most vital problems in the effort to establish closer relations among the American Republics.

"We think it should be made a matter of care that your great commercial centers should be connected with those of all the world on an equal basis," he said. "It should be as cheap and convenient for you to communicate from your cities with ours as with those of Europe. At present it is possible for you to cable from some of your cities to European points at a considerably less cost than to our own, and in some cases the difference is striking. Without knowing how far this matter may be within the direct control of your several Governments, it seems to me that a sound policy can be laid down on this subject in this way: It should be as easy and as cheap for all America to communicate with itself as it is for it to communicate with lands across the

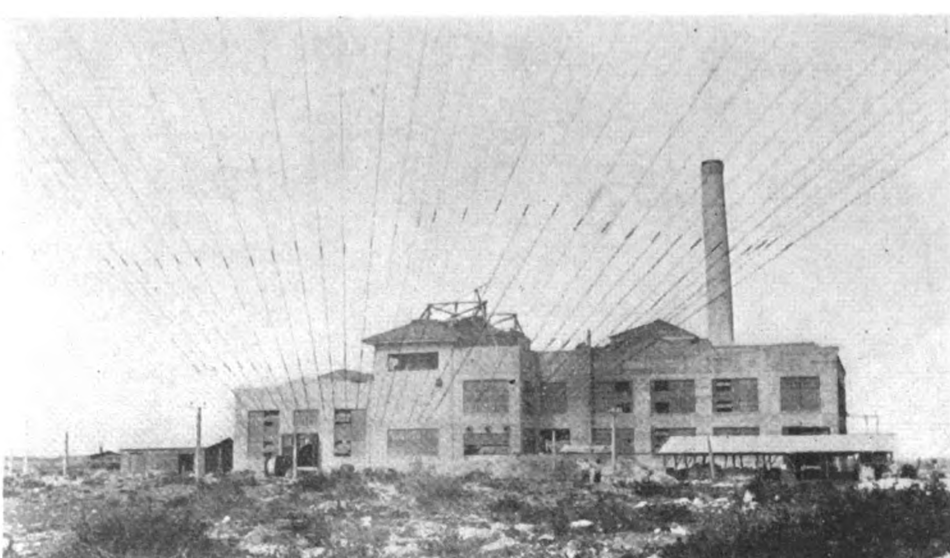
sea. There ought to be no handicap of telegraphic rates between American countries in favor of European ones. We of America are in a sense of one international family, and we should see to it that the family is not at a disadvantage in this important respect. There is another thing incidental to what I have said, greatly needed in South and Central America concerning us of the north, and that is some systematic and reasonably accurate news service which shall not publish throughout all our sister nations the small and the narrow and the poor and the bad exclusively. I have discussed this important question with the managers of our leading press associations, and they deplore it, but find themselves for the moment helpless concerning it. There is no direct cable communication now, they tell me, for press dispatches, for example, with the cities of Buenos Aires and Rio de Janeiro, and I feel that we suffer in the eyes of our brethren at the south for lack of a truthful picture of us presented every day in the columns of the daily press in the cities of Spanish America."

In the letter to the President of the United States from the Secretary of the Treasury, transmitting the proceedings of the Conference, Mr. McAdoo wrote:

"Another subject of very great importance is the need of direct cable communications and reasonable rates between the Latin American countries and the United States. This was emphasized by many delegates in the Conference. There is no doubt about the disadvantages under which all of the countries of Latin America and the United States labor on account of the present roundabout and unsatisfactory facilities and the excessive cost of cable communication between them."

Among the reports of the General Committee on Transportation and Communications, prepared in each case by representatives of all the countries, the following two, referring specifically to Argentina and Brazil, are almost identical with the reports of other delegations. The report on Argentina regarding this question contains the resolution:

"Whereas, in view of the great distance and slow mail facilities existing between the Argentine Republic and the United States, the matter of quick



Typical power plant of a Marconi long-distance station, showing aerial wires leading in

communication between the two business communities is of vital importance to the development of trade,

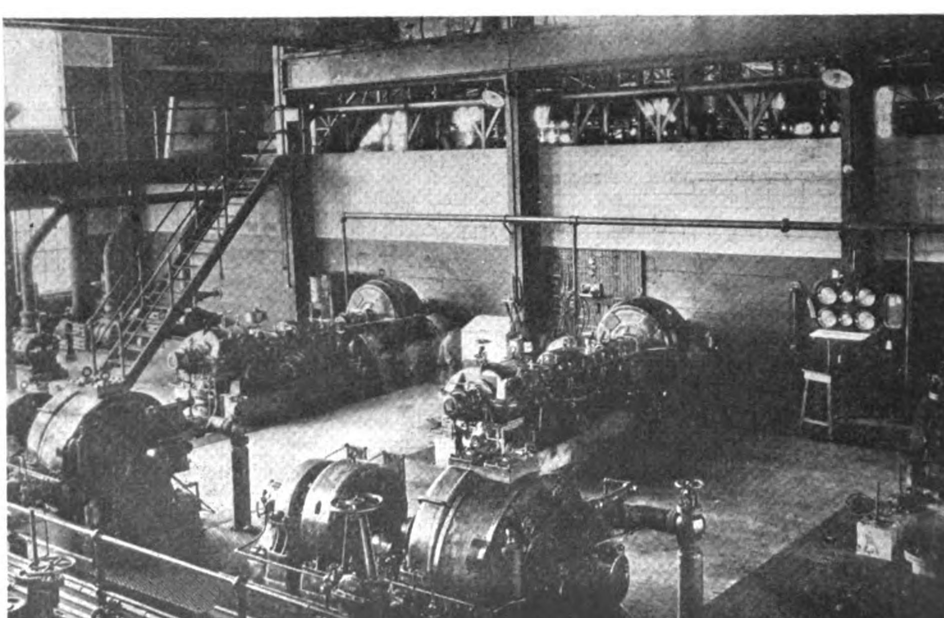
"Now, therefore, be it resolved, that this conference bring to the attention of the Governments of both nations the need for cheaper telegraphic communication and that they be urged to take any proper and necessary action tending toward the establishment of lower rates for direct telegraphic communication in co-operation, when desirable, with other Latin American countries."

The recommendations of the Brazilian Committee still further emphasized the importance of the subject by direct and specific proposals of the very nature contemplated by the Pan-American Wireless Telegraph and Telephone Company. That committee's views were embodied in two significant paragraphs:

"We urge the extension of direct telegraphic service, either wireless or cable, between all parts of North, Central and South America, to be owned, controlled and operated by exclusively American interests.

"We recommend to the press of all the interested countries that a more comprehensive and reliable system for the exchange of important news items be established."

These passages from the official speeches and documents not only express with high authority the true needs of the prevailing situation, but they also assure the complete and hearty co-operation of all the American Governments in the furtherance of the great work undertaken by the new company. Every one of the points urged by the authorities quoted is embraced by the plans of the company. By reason of high-speed operation and favorable rates it is also proposed to offer inducements to newspapers and press associations to send and distribute reports and dispatches of greater length and with greater frequency than is possible under present conditions; and, as a result of such improved facilities, to bring about a generous interchange of news dispatches between all the different countries, thereby enhancing their friendly relations as well as serving their trade interests. Further develop-



Interior view of a Marconi power plant for trans-ocean stations, illustrating the magnitude of the task of linking up the Americas

ments contemplated by the Pan-American Company also include the transmission of night and week-end letters at greatly reduced rates, a service which has proved very popular in trans-Atlantic and trans-Pacific wireless telegraphy, and other innovations of a like character. Another sphere of operation to which the company's service will extend is, as its name indicates, that of wireless telephony, which is being developed with remarkable rapidity and success; and there is little doubt that within a measurable distance of time an important part will be played by that method of communication in long-distance messages as well as from ship to shore. There is also a wide field for a use of the wireless telephone for vessels too small to permit of carrying an operator for wireless telegraph communication. Equipped with a simple wireless telephone, the operation of easily communicating with lightships, shore stations and passing craft could be conducted by any of the ship's officers; and with a view to the early introduction of this branch of the service the company has acquired new inventions which will add considerably to the speed, the selectivity and the secrecy of the service.

The organization of the Pan-American Telegraph and Telephone Company has been effected under the most favorable conditions with every moral and material guarantee for the fulfillment of the important objects it has undertaken to accomplish. It is strengthened by the capital and large resources of the Marconi Wireless Telegraph Company of America, and its engineering and technical staffs include a number of the leading experts in wireless telegraphy, some of whom have brought about the many improvements in the trans-oceanic stations. It is even still more encouraging to note that the company expects that the first important step of establishing direct wireless communication between New York and Buenos Aires will be completed within twelve months. Thus, it is safe to assume that the final realization of an all-American system of wireless communication will eventuate within a shorter time than was ever thought possible by the representatives of the various American Republics who so strongly pressed the idea two years ago. The fact that the task is one of no light order may be gathered from the accompanying illustrations. Even these do not convey an adequate impression of the elaborate and delicate machinery, extensive plant and construction required for the proper equipment of high-power stations for long-distance wireless service; and when it is considered that suitable sites have to be located and acquired, each of which must be provided with a sufficient area to permit of the erection of the various buildings and steel masts, the completion of the South American service abundantly demonstrates the measure of the company's resources and capacity.

WINDSOR CASTLE.

Soldiers of the United States, the people of the British Isles welcome you on your way to take your stand beside the Armies of many Nations now fighting in the Old World the great battle for human freedom.

The Allies will gain new heart & spirit in your company.

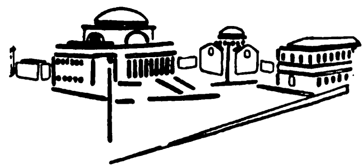
I wish that I could shake the hand of each one of you & bid you God speed on your mission.

George R.I.

April 1918.

The letter of welcome from King George of England, a facsimile copy of which was given to every American soldier arriving in Great Britain

Progress in Radio Science



The Use of Telegraph and Telephone Lines

IF a radio frequency current is induced in an electrical conducting circuit of inordinate length, there will be nodes and loops of potential at various points along the wire. If a voltage-operated radio receiving detector is connected to this conductor at the point where the voltage is maximum, response will be obtained from wireless transmitters.

An apparatus has recently been shown by Elmer E. Bucher wherein telephone, telegraph, or power-line conductors can be employed as collectors of radio frequency energy, and by associating therewith an open circuit oscillator such as shown in the accompanying drawing, figure 1, radio signals may

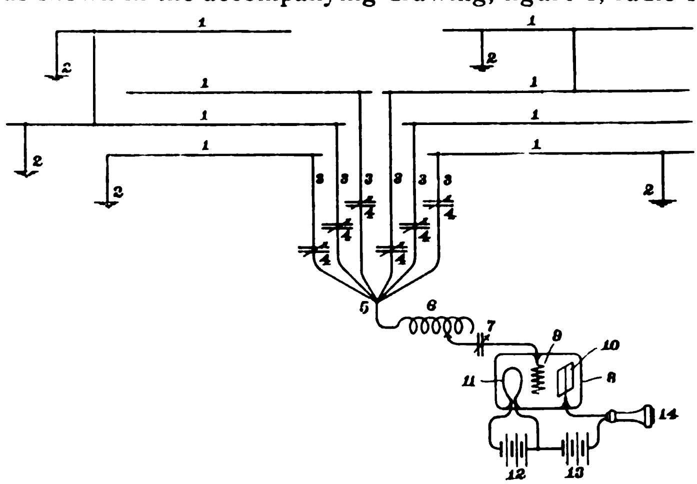


Figure 1—Diagram showing telegraph, telephone or power-line conductors as collectors of radio frequency energy

be received over considerable distances. In the diagram, telephone or telegraph conductors are shown at 1, being earthed at the point 2. In order not to interfere with the carrying on of telegraph or telephone communications they are connected together through condensers of small capacity joining in a common terminal at 5, and ending in the coil 6, the variable condenser 7, and the grid element 9 of a three-electrode valve. It is not necessary in a system of this kind that the conductors 1, be tuned to the periodicity of the incoming oscillations, but it is essential that the circuit 6, 7, 9, have a natural frequency of oscillation equal to that of the incoming signals. By proper adjustment of the condensers 4, it is possible in this circuit to cause a loop of potential to take place at the free end of the coil 6, and therefore upon the grid element of the valve 9.

Novelty in Spark Design

A FAVORITE form of impulse excitation transmitter is the one employing a multiple gap. It has been shown that in order to bring about excitation by impulse of an oscillating circuit, it is advisable to use multiple spark gaps

with a very short discharge gap and a number of spark gaps in proportion to the voltage brought into play. The impulse effect, in general, is more accentuated with short discharge gaps.

Various designs have been laid down from time to time for the construction of such spark dischargers, but many lead to excessive heating, either in consequence of the enclosure of the gap or as the result of the shape of the electrodes. In respect to the latter, their design may not permit the continual displacement of the sparks on the surface of the electrodes.

The method of construction recently described by E. Guardeau and J. Bethenod, shown in figure 2, greatly facilitates the cooling, and at the same time simplifies the construction.

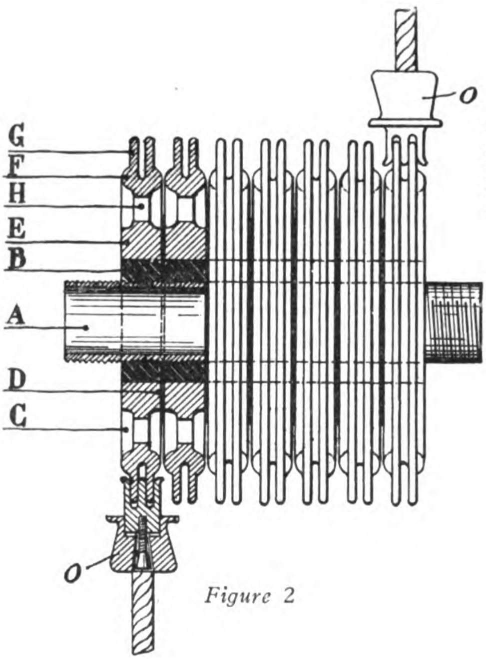


Figure 2

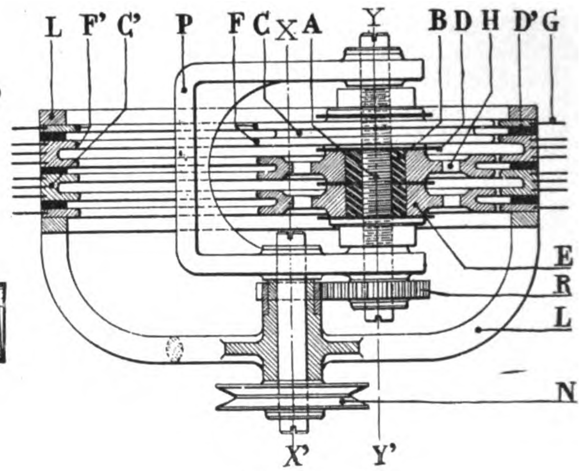


Figure 3

Figure 2—Simplified construction of spark gap for high powers with improved cooling facilities

Figure 3—Spark gap employing a form of rotary gap to cool the electrodes

In this figure, A is a plain hollow cylinder of hard metal, on which are threaded rings of insulating material B; on the latter the electrodes fit snugly and a mica washer D of very accurately gaged thickness is placed between two consecutive rings B; finally, the electrodes C are constructed in the form of disks comprising a hub E and a double swelling F, the axial thickness of which is equal to that of the hub E and of the ring B.

Constructed in this way, the sparking distance between two consecutive electrodes is equal to the gaged thickness of the washers D, and the spark discharges between the swellings F opposite the two consecutive electrodes, the external diameter of the washers D being of the proper thickness to prevent any sparking between two adjacent hubs.

Since the adjustment of the various parts is easy and may be effected with very great precision, it being assumed that one is only concerned with tuned parts, the exact parallelism of the electrodes is insured, and the spark discharges throughout the active surface of the electrodes.

In order to insure the cooling of the electrodes, which is indispensable to the satisfactory working of the spark gap, the latter terminate in vanes G. They also are pierced with several holes H, through which air circulates. The ribs G serve at the same time as a connection to the external circuit, permitting any number of gaps to be employed.

While the spark gap shown in figure 2 may be employed for high powers,

it is advisable to employ some form of a rotary gap embodying the foregoing principle. This prevents consumption of the electrodes. The construction shown in figure 3 satisfies the above mentioned requirements.

In this spark gap half the electrodes are fixed and the other half are movable. A metallic frame L supports the fixed electrodes C^1, which are in the form of rims and carry two swellings F^1, which constitute the active surfaces. These electrodes are provided with vanes G to insure the cooling thereof, and are insulated from one another by washers of mica (or other insulating material). This is indicated at D^1. The plates are then pressed against one another by any suitable locking device. The mounting of the movable electrodes is exactly the same as that shown in figure 2. They are supported by a shaft A, on which are fitted the insulating rings B. On the latter are fixed the electrodes C, which are insulated from one another by mica washers D.

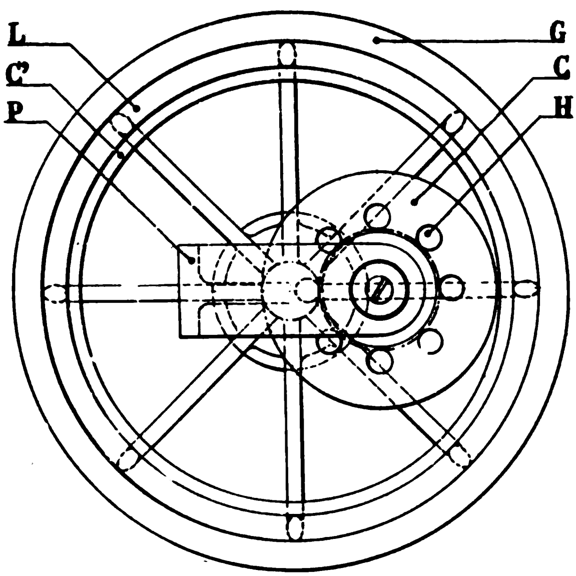


Figure 4—Plan view of the spark gap

The shaft A may be rotated by a system of gearing H controlled by a pulley N, which makes the entire system rotate about the axis XX^1 and at the same time makes the shaft A rotate about the axis YY^1. In this way the points of discharge of the sparks are continually renewed, which insures proper cooling. Figure 4 is a plan view of the spark gap.

A Spark Gap Designed to Reduce Resistance

A SPARK discharger designed to reduce resistance between electrodes by introducing a highly ionized gas between them has been described by William Walker Strong. An object of his invention is to produce unidirectional currents, from an alternating current by introducing a surface giving off ions of a definite single sign in the alternating current circuit.

A further object is to present a method of destroying or preventing an oscillatory discharge between spaced apart electrodes when the current between the electrodes is started or stopped.

It is well recognized in the art that the presence of ions in a gas between spaced metallic electrodes serves to carry the current between the electrodes. If these ions are free to move and are sufficiently numerous they will cause the difference of potential between the electrodes to be decreased. In other words, the presence of these ions makes the gas a conductor, and the con-

(C) Comm. Pub. Info.

The oft-repeated query as to whether the Marines have a Signal Battalion is answered in this picture of a radio section of the "Teufel Hunden" taking down military messages in France. Those among this magazine's readers who are anxious to take the trip overseas with the Marine Corps may note that the home station of the Signal Battalion is in Philadelphia, where a training school is maintained, Major J. J. Meade, commanding, who endorses the statement that just now unprecedented opportunity is given applicants experienced in radio or wire telegraphy. An invitation to write Major Meade personally is cordially extended to all prospective applicants

ducting property of the gas will depend upon the density and number of ions; the value of their electrical charge; and the ease of mobility with which the ions move. Since electrons are at present generally recognized as the smallest ions, they are therefore better able to satisfy the above specified conditions, and consequently are better carriers of the electric current than any other known kind of ion.

Strong's method of decreasing resistance between gap electrodes consists in producing a large number of ions, possessing as high a mobility as possible, between the electrodes at times when the electric current is flowing between the electrodes. On account of their mobility, it is obvious that the production of electrons is preferable to the other kinds of ions. Many kinds of ionizing agents may be used for this purpose; for example, the ions may be produced by radiations from radio active substances; from electrical discharges, such as the well known X-ray, and other rays of this character; or from incandescent bodies.

For many purposes the use of incandescent bodies is preferable for carrying out the method, because incandescent surfaces are easily produced or obtained and the ionization is localized near the surface of such a body.

The ionization of a gas near the surface of an incandescent solid depends upon the temperature of the solid; the nature of the solid; the condition of its surface; and the value of the electric and magnetic fields in the region where the ionization is being produced. There are two types or kinds of ions, that is, positive and negative ions. It is well established that the positive ions are of molecular magnitude or larger, while the negatlve ions are much smaller and often electrons. By suitably selecting the temperature, the condition of the incandescent surface, the values of the electric or magnetic fields, the relative and absolute number of positive and negative ions may be controlled or modified. By suitably arranging conditions to produce ions of substantially one sign only, it is possible to obtain a uni-directional current from an alternating current acting between electrodes, for the reason that if an electrode is giving off ions of a single sign it will assist, or at least not resist the current flowing in one direction, but will greatly resist the flow of the current in the opposite direction.

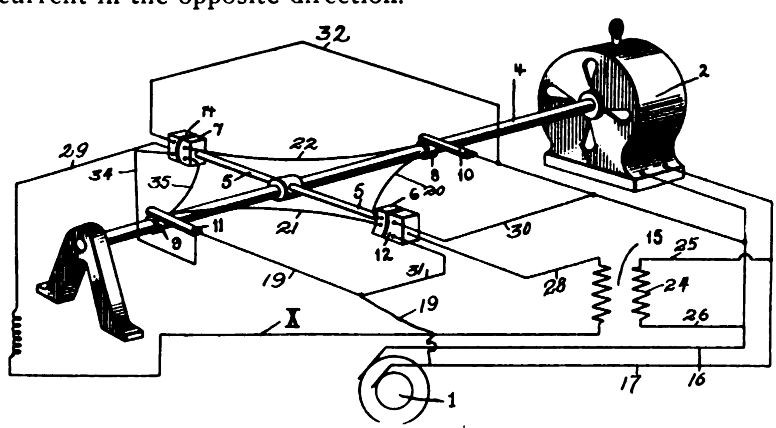


Figure 5—Spark gap designed to reduce resistance

There are several means by which a solid may be raised to incandescence. For example, a beam of radiation such as heat may be focused upon the solid; the solid may be heated by an electrical current, or it may be placed in or near the region where a chemical reaction of great heat producing power is taking place. A concrete case of the latter type is the raising of surfaces to incandescence by means of surface combustion. Surface combustion consists in the burning of a homogeneous mixture of two gases such

as air and illuminating gas (in proper proportions for complete combustion) without flame, in contact with a granular incandescent solid whereby a large part of the energy of combustion goes to heating the incandescent solid. For example, the mixed gases may be admitted to the rear of a porous granular diaphragm of heat resisting material and the mixture fired as it comes through the pores of the diaphragm. As soon as the diaphragm becomes hot the combustion takes place entirely within the granular diaphragm without flame and the outer surface of the diaphragm becomes very hot, while the inner surface may be kept comparatively cool dependent on the speed of the incoming gas. By this method very high temperatures may be obtained.

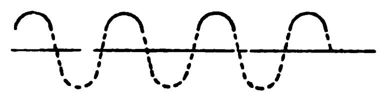


Figure 6—A portion of an alternating electric wave

One form of this apparatus is shown in figure 5 and in figure 6 a portion of an alternating electric wave that is transformed into an intermittent uni-directional current by the use of the apparatus and method diagrammatically shown in figure 5.

Another form of apparatus shown in figure 7 permits an alternating current to be resolved into two intermittent uni-directional currents.

Figure 8 illustrates the portions of an alternating current which are transformed into uni-directional currents by means of this system.

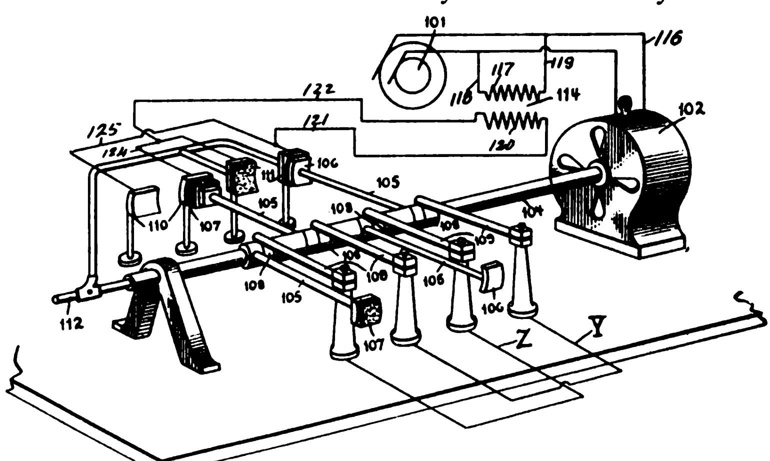


Figure 7—Apparatus designed to change alternating current into two intermittent uni-directional currents

Figure 9 illustrates one form of electrode which may be employed to carry out the objects of the invention.

Referring to figure 5 in which all of the parts or elements are diagrammatically represented, the alternating current generator 1, which is a source of supply, is directly connected to a synchronous motor 2 by means of the conductors 16 and 17 in such a manner that the motor will run in synchronism with the generator. A driver shaft 4 is properly mounted in suitable bearings, and carries a metallic conducting arm 5. On the outer ends of this arm are mounted electrodes 6 and 7. Each of these electrodes is provided with an outer surface capable of being heated to incandescence by means of a small electrical furnace contained within the electrode. The current to the electrical furnace being furnished through collector rings 8 and 9, by means of brushes 10 and 11. The brush 10 is connected by the conductor 18 with the main feed wire 16 and the brush 11 is in like manner connected by means of

the conductor 19 with the main feed wire 17. The conductors 20 and 21 connect the heating element in the electrode 6 with the collector rings 8 and 9 respectively thus completing the circuit to supply the current to heat the electrode 6, and the conductors 22 and 23 similarly connect the collector rings 8 and 9 with the heating element in the electrode 7. Stationary electrodes 12 and 14 are provided with inner surfaces which may be also heated to incandescence by means of electrical furnaces, the currents of which may be supplied in any suitable and proper manner. For example, the heating element in the electrode 12 may be supplied with electricity through the conductor 30 connected with the lead 18 and the conductor 31 connected with the lead 19, while the heating element in the electrode 14 may be supplied with electricity through conductors 32 and 34 connected to the leads 18 and 19 respectively. A transformer 15 is arranged with its primary 24 connected with the generator by means of the conductors 25 and 26 and its secondary 27 connected by means of the conductors 28 and 29 with the stationary electrodes 12 and 14 respectively, thus forming a circuit X, the intermittent unidirectional current of which may be utilized for any desirable purpose.

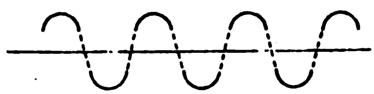


Figure 8—Showing portion of alternating current which is transformed into uni-directional current

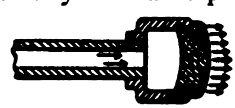


Figure 9—Form of electrode employed in apparatus

To put this apparatus in operation the transmitting surfaces of the moving and stationary electrodes are raised to incandescence; the synchronous motor 2 is run in step with the generator so that the moving electrodes are passing the stationary electrodes when the alternating wave has reached its crest on the positive side. Since the electrodes are very highly heated, any gas near their surfaces is in a high state of ionization, and therefore when the moving electrodes pass near or over the stationary electrodes, the incandescent surfaces of the stationary electrodes and the moving electrodes are brought very near together and the spaces between these electrodes are filled with a highly ionized gas. Consequently resistance to the passage of the electricity between these points is very greatly diminished.

Figure 7 shows a mechanism wherein certain of the electrodes comprise surfaces of combustion. In this figure the diagrammatic representation of an alternating current generator 101, which is the source of electricity, is directly connected to a synchronous motor 102 by means of the conductors 115 and 116 respectively, which rotates a drive shaft 104. The drive shaft 104 is properly mounted in bearings and carries a plurality of metallic arms 105, upon the outer ends of which are mounted metallic electrodes 106 and surface combustion electrodes 107. The drive shaft 104 is hollow up to the arm carrying the second electrode provided with a surface combustion plate. The arms for the surface combustion electrodes 107 are also hollow tubes and serve as conductors to lead a proper combustion mixture to the electrode surface combustion faces. Each of the moving electrodes is electrically connected with its respective collector ring 108, which are all insulated one from another, and each collector ring is provided with a brush 109. There are stationary electrodes provided for each movable electrode, and metallic stationary electrodes 110 are provided to co-operate with the movable surface combustion electrodes 107, and stationary surface combustion electrodes 111 are provided to co-operate with the movable metallic electrodes 106. A proper combustible gaseous mixture is fed to the surface combustion electrodes by any convenient means, such as for example, the supply pipe 112. A transformer 114 is arranged with its primary 117 connected by conductors 118 and 119 to the generator, and its secondary 120 is arranged with each end

respectively attached to a metallic stationary electrode and also to a surface combustion stationary electrode, by means of the conductors 121 and 122 which connect with the conductors 124 and 125 that are each respectively connected to a stationary metallic electrode and to a stationary surface of combustion electrode.

The brushes 109 are connected in circuits Y and Z in such manner that as the synchronous motor 102 runs in synchronism with the generator one circuit will be completed when the alternating wave has reached its positive crest and the other circuit will be completed when the alternating wave has reached the negative crest, thus the result will be two independent unidirectional currents, one over the circuit Y and the other over the circuit Z. It will be noted that the surfaces of combustion are all so arranged that the current each time leaves the surface in the same direction. For example, figure 7 is shown with the circuit Y as being excited. The current enters the stationary surface combustion electrode 111, passes into the movable metallic electrode, completes the circuit through the brushes and outer circuit, leaves the movable surface combustion electrode 107 and enters the stationary metallic electrode 110. In each case it will be noted that the current passes from a surface of combustion into a metallic electrode.

Protection for Wireless Aerial in the Submarine Zone

THE present war has brought forth some curious yet highly practical inventions. Explosions in vessels, due to torpedoes or contact with floating mines, etc., have put ships' masts supporting the wireless antenna to such strain as to break the aerials and to prevent calling for help. We are informed by the "Telegraph and Telephone Journal" of England, that a patent has recently been granted by the British Government to Mr. S. Hall, for a device which reduces to a minimum the risk of wireless aerials on vessels being broken and the wireless apparatus thus put out of connection. The invention utilizes one or more long extension springs, specially constructed and fitted at each end of the present aerial. These springs automatically expand and contract to allow the aerial to lengthen or shorten or to take up the varying distances at the top of the masts when they spring out of position through explosion. These springs do away with the necessity of lowering the aerial when the ship is being loaded, as they allow for the vibration of the masts caused by working the derricks, and they would, in fact, in some cases save the aerial from being blown away by shell fire.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XVI

By Elmer E. Bucher

Director of Instruction Marconi Institute

EDITOR'S NOTE—This is the sixteenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustments of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

RECEIVER TUNING APPARATUS

DISTRIBUTED OR SELF CAPACITY OF TUNING COILS AND END TURNS

(1) Tuning coils possess **distributed** or **self-capacity**; that is, if an oscillatory E. M. F. flows in the coil, energy is stored between turns in the form of an **electrostatic field.** This causes the coil to act as an oscillation circuit. That is, it will have a well defined period of oscillation, and if it is employed as a tuning element in a radio frequency circuit, considerable energy will be absorbed—particularly if its natural frequency coincides with the incoming signal.

(2) In general, **self-capacity** is undesirable in tuning coils except in cases where the coil is used as the secondary tuning inductance and is to be operated over a limited range of wave lengths. In this case, its self-capacity may take the place of the usual shunt condenser.

(3) If a tuning inductance is designed to operate over a wide range of wave lengths and only a portion is used for a particular wave length there will be a number of **unused** turns attached to the circuit which play no part in the adjustments for resonance but absorb energy from the incoming signal.

(4) Modern tuning coils are equipped with end turn switches through which the windings are split into groups. Each group gives a definite range of wave length, and since the unused turns are not conductively connected to the used turns, losses which heretofore were experienced in such coils are partly prevented.

INDUCTANCES

(1) **Single** and **multiple layer tuning coils** are in use.

(2) The turns of multiple layered coils are **"banked"** to reduce their self-capacity.

(3) In the early types of radio frequency tuning coils the inductance was varied by sliding a ball or flexible strip over the bared portion of the coil. This arrangement obviously did not prove practical, because adjacent turns were soon short circuited, rendering the coil inoperative.

(4) In order that the requisite selectivity may be secured, tuning coils should be designed so that their inductance can be varied by at least **a turn at a time.** Through the use of two multi-point switches known as a **"tens"** and a **"units"** switch, the number of turns included in a given tuning circuit may be varied between one and maximum by single turns.

(5) Tuning inductances consisting of two fixed inductances in variable magnetic relation (often termed variometers) have been successively employed.

BUZZER EXCITATION SYSTEMS

To permit the receiving operator to pre-determine the most "sensitive" adjustment of the receiving detector, a **simple buzzer** may be employed to induce feeble currents in the receiving system. If some part of the buzzer circuit is inductively coupled to the antenna system, the aerial will be impulsed periodically and **set into oscillation** at whatever frequency it is adjusted. Various methods of coupling the buzzer to the tuning circuits are in use.

MICROPHONIC RELAYS

Incoming radio signals may be amplified by the use of **microphonic relays.** They have not been employed extensively although good results have been secured.

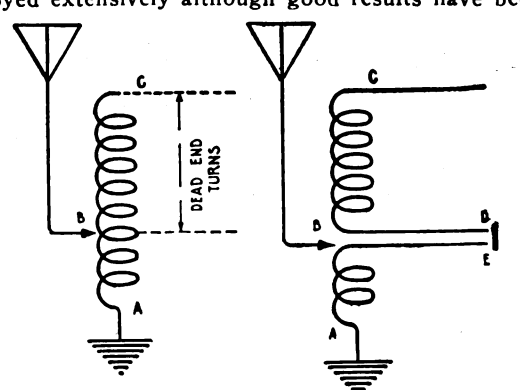


Figure 149—Diagram showing the "end turns" or "unused" turns of a radio frequency inductance. The coil A, C, is a radio frequency tuning inductance which is employed to tune the antenna circuit to various wave lengths. Suppose, for example, to establish resonance at the wave length of 600 meters only the turns between A and B are required. If the natural frequency of the coil A, C, is the equivalent of the wave length of 600 meters, part of the energy of the incoming oscillations will oscillate through the unused turns resulting in a decrease of the strength of signal. If the circuit is interrupted at points D, E, as shown in the right-hand part of the diagram, the "end turns" losses are greatly reduced.

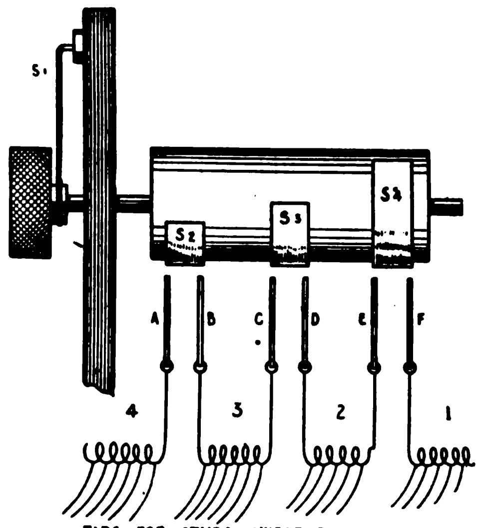


Figure 150.

OBJECT OF THE DIAGRAM

Figure 150. To show the fundamental construction of the "end turn" switch employed in Marconi receiving tuners.

PRINCIPLE

It is desirable to cut off the unused turns of a radio frequency inductance in cases where the entire coil is not required for a given wave length.

DESCRIPTION OF THE DRAWING

The blade of the switch S-1, figure 150, makes contact with studs mounted in a circle to which are attached the taps 1, 2, 3, 4, leading to the tuning coil. A barrel switch operating in conjunction with the inductance changing switch carries brushes A, B; C, D; and E, F, which make contact with the copper segments S-4, S-3, S-2, successively.

OPERATION

Assume, for example, that higher inductance values than those furnished by the group 1, are required. The knob of the switch S-1 is turned counter-clockwise whereupon the copper segment S-4 makes contact with the brushes E, F, connecting the group 2 in the circuit. As the switch S-1 passes over the taps connected to group 2, the segment S-3 makes contact with brushes C, D, throwing group 3 in the circuit, and so on throughout the series.

SPECIAL REMARKS

(1) An end turn switch is provided for both the primary and the secondary coils.

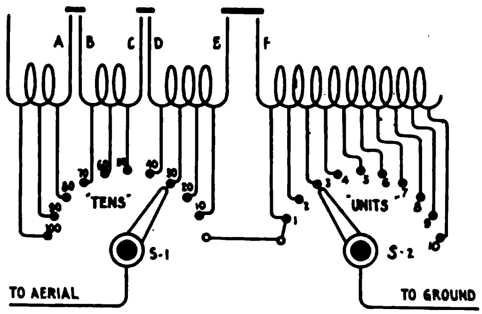


Figure 151

OBJECT OF THE DIAGRAM

To show how the inductance of a radio frequency tuning coil can be adjusted by one turn at a time.

DESCRIPTION OF THE DRAWING

The contact points of the switch S-2 are connected to the first ten single turns in the coil. The studs of the switch S-1 are connected to each tenth turn progressively.

The coil is interrupted by an end turn switch at the points A, B; C, D; and E, F.

OPERATION

Assume, for example, that the operator desires to connect 37 turns in the circuit; switch S-1 is set on the contact marked 30, and switch S-2 on the contact marked 7, the circuit between the single turn switch and the additional groups being closed at E, F, by the end turn switch.

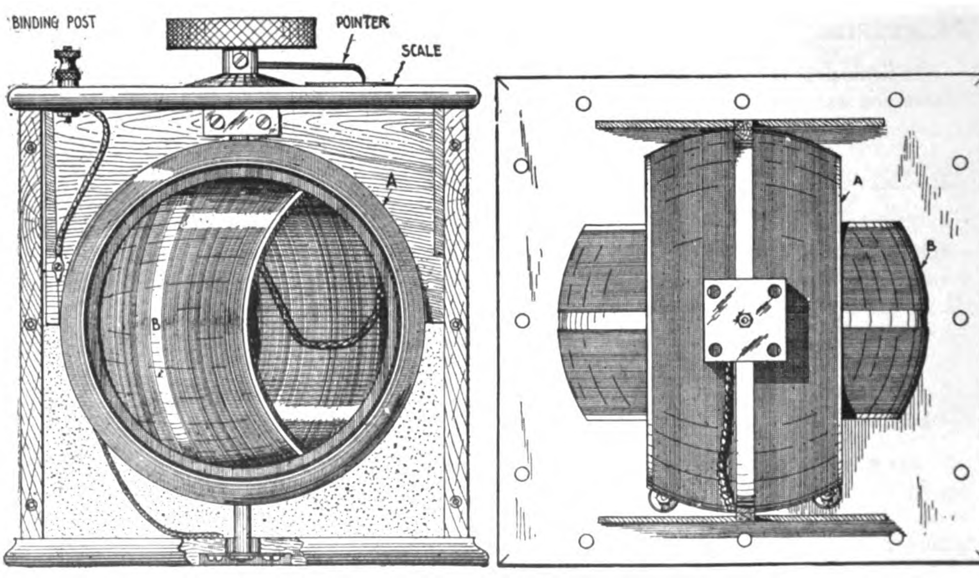


Figure 152, Figure 153—Showing the construction of a variometer adaptable to radio frequency tuning in receivers. Mounted inside the stationary coil A is the ball winding B, which rotates on a shaft. A knob and a pointer is attached to the shaft passing over a suitable scale cut in the cover. Coils A and B are connected in series. The inner coil moves through an arc of 180°. In one concentric position the magnetic fields of the two coils oppose, and the inductance of the variometer is practically zero. In the opposite concentric position, the inductance is maximum. At intermediate points the inductance varies as the angle of the coils.

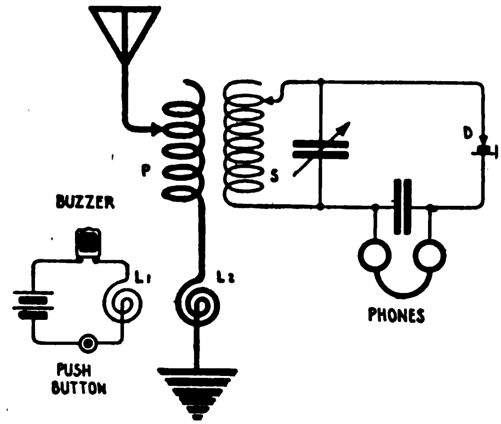


Figure 154—Showing how a buzzer excitation system is coupled to a receiving circuit. The object of this apparatus is to permit the receiving operator to adjust the receiving detector to its best operating condition in advance of the reception of signals from a given transmitting station. The coil L-1, which is part of the complete buzzer circuit, is placed in inductive relation to the earth lead of the antenna circuit at L-2. When the buzzer is in operation, an E. M. F. is impressed across the coil L-2 setting the antenna circuit into oscillation at whatever frequency it happens to be adjusted. Oscillations of similar frequency are induced in the secondary circuit and are rectified by the detector D, response being obtained in the head telephone. The operator tries various points of contact on the crystal until maximum response is secured. The buzzer system may be conductively as well as inductively coupled to the antenna circuit.

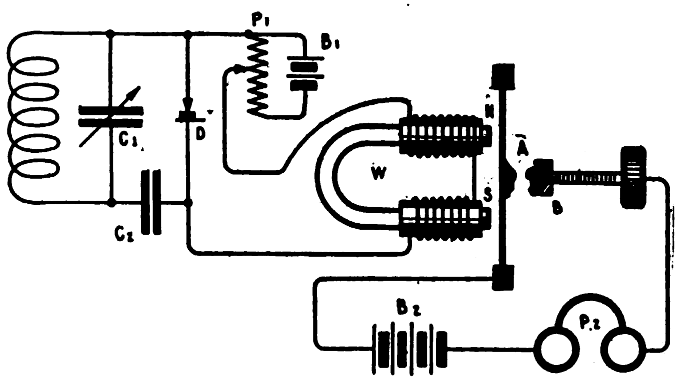


Figure 155

OBJECT OF THE DIAGRAM

To disclose the fundamental principle of the microphonic relay.

PRINCIPLE

By attaching a microphone to the diaphragm of a receiving telephone, the vibrations of the diaphragm may be magnified in another telephone receiver through the use of a local battery.

DESCRIPTION OF THE APPARATUS

The secondary circuit of the receiving tuner is represented by the usual tuning elements. The circuit of the battery B-1, potentiometer P-1, and the crystal D, being completed through the magnet windings W. The poles of the magnet N, S, act upon the telephone diaphragm P which carries the carbon button A. The carbon button B is mounted so that its pressure on A can be closely adjusted. The complete microphone circuit includes the carbon buttons A, B, the telephone P-2, and the battery B-2,

OPERATION

During the reception of signals, the crystal detector is adjusted to its best operating condition by means of the potentiometer P-1. The operator then adjusts the pressure on the microphonic contacts A, B, until the loudest response in the head telephone is secured.

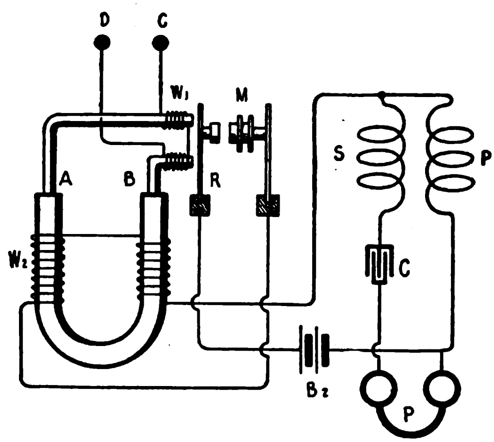


Figure 156—Showing the construction of the supersensitive Brown amplification relay. M is a microphone chamber field with carbon granules, the pressure of which can be carefully regulated by means of an adjusting screw. The vibrating tongue R is actuated by the flux of the poles A, B. The current to be amplified enters the winding W-1 at the terminals C, D. The vibrations of the diaphragm R vary the resistance of the microphone M. The resulting fluctuations of current in the local circuit (fed by the battery B-2) flow through coil P and also through the winding W-2 which acts to increase the amplitude of the vibrations of R. The potential of the resulting fluctuating current is increased through the transformer P, S, the circuit from S to the telephone including the condenser C. Condenser C has about 2 microfarads capacity and the battery B-2 has an E. M. F. of approximately six volts.

ATMOSPHERIC ELECTRICITY (STATIC)

A serious interference encountered in wireless telegraph stations throughout the world is that due to vagrant electrical waves which will set a receiving antenna into oscillation at the frequency to which it is adjusted.

Widely varying theories exist as to the origin of these electrical waves, but a considerable amount of this interference is set up by nearby or far-distant electrical storms.

These interfering waves are sometimes termed **atmospheric electricity.** In foreign countries they have been given the name of **"atmospherics"** or **"strays."** The popular term in the United States is the word, **"static."**

The currents induced in the receiver by "strays" causes a crackling irregular sound of greater or lesser intensity in the receiving telephone which may interfere to a marked extent with the reception of radio telegraphic signals. Three kinds of "strays" are recognized in practice:

(1) Those known as "grinders," consisting of a more or less prolonged rattling or grinding noise;

(2) Strays consisting of sharp isolated knocks, termed "clicks";

(3) Strays consisting of a buzzing or frying noise, called "hums" or "sizzle."

The latter are often observed as an accompaniment to a squall or a snow storm.

It may be said that the origin of these atmospheric discharges is not fully understood, and so far they have presented a problem which has not been completely solved.

To reduce the interference of "strays," the transmitting apparatus is designed to produce a spark note of high pitch having a more or less musical tone. The telegraphic characters can then be readily distinguished at the receiving station due to the difference in pitches of the interfering "strays" and that of the spark at the transmitting station.

Modern transmitters energized by 500 cycle alternating current produce a musical spark note which permits communication to be carried on through "strays" which would not be possible with a spark gap giving a note of non-uniform pitch.

When the receiving apparatus is connected to very large aerials severe static interference is obtained throughout the day and night, and in order to carry on communication through this interference, a transmitter of very great power is required that will permit the desired signals to be heard over the interfering sounds.

The effects of atmospheric electricity are overcome

(1) by the employment of large powers at the transmitting station (much in excess of that required in the absence of atmospheric electricity);

(2) by reduction of coupling at the receiving transformer.

A special receiver has been devised by Marconi to eliminate the crashing sounds of atmospheric discharges in the telephone.

The apparatus carrying out this principle is known as the balanced crystal receiver, in which two oscillation detectors are connected in opposition. The effect of this mode of connection is to limit the maximum sound created in the head telephone by atmospheric discharges. The operator's ears are thus protected from the heavy crashing sounds which ordinarily would be obtained from the head telephones.

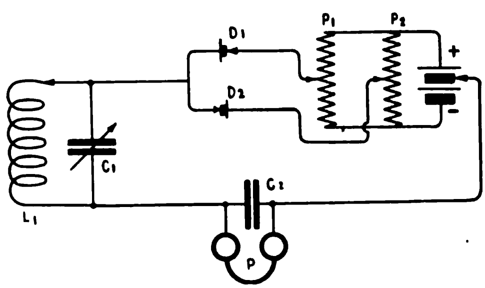


Figure 157

OBJECT OF THE DIAGRAM

To show the circuits of the Marconi balanced crystal receiver.

DESCRIPTION OF THE DRAWING

In figure 157 two carborundum crystals, D-1 and D-2, are connected in the receiver circuit in such a way as to oppose each other's effects. Both crystals should have nearly identical operating characteristics, but they are not worked at the same point on the characteristic curve; that is, they are not adjusted to the same degree of sensitiveness.

OPERATION

If the crystals D-1 and D-2 are adjusted to be equally sensitive to the incoming oscillations (by their potentiometers) no sound will be produced in the head telephone P.

If, however, crystal D-1 is adjusted to a "sensitive" state and crystal D-2 to a slightly less sensitive state, an incoming signal of a small E. M. F. will produce sufficient change of current in the head telephone P to create a sound. On the other hand, if a severe discharge of atmospheric electricity strikes the aerial, the local currents of crystals D-1 and D-2 will reach almost identical maximum values (approach the saturation point) and will almost completely neutralize. In other words, strong signals or strong discharges of atmospheric electricity will cause greater opposition between the crystals than weak signals. Hence, the sound produced by the telephone is limited, and the operator's ears are accordingly protected leaving them in a "sensitive" condition to receive the desired signal.

(C) Int. Film Svce.

A portable wireless station established for communication under a white canvas shelter appears, in this instance, to point the finger of scorn at what we have thus far considered necessary in the way of camouflage. The station is Bulgarian, according to the correspondent who secured the photograph and is considered of high efficiency by that nation of disturbers of Europe. Apparently the equipment consists of sending and receiving radio instruments with the usual telephone accessory. The presence of the reel device on the table leads one to assume that it is either a tape receiver or a Wheatstone transmitter. Why automatic transmission of military messages should be thought advisable is not clear in view of the constant cry for haste in war intelligence. Assuming the Wheatstone eliminated by this handicap, there remains consideration of the device as a tape recorder, which in turn is cause for speculation as to whether the Bulgars are still back in the coherer stage of radio or are springing something entirely new

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

By Major J. Andrew White
Chief Signal Officer, American Guard

FIFTEENTH ARTICLE

Field Lines

GENERAL PROVISIONS

FROM instruction with the buzzer the work will be carried on in actually laying field lines on the drill ground or along such roads as are available. The units for this work will be the section, platoon, and company. Whether operating alone or in combined training each section lays, operates, and maintains its own line. Two kinds of wire are provided for this work: The 11-strand field wire, which will be used when possible, and the 3-strand buzzer wire.

THE WIRE CART

The means provided for laying field lines is a wire cart, with drums and an automatic gear for picking up the wire when driving back over the line. This is supplemented by carriers for buzzer wire to be used by men on foot or mounted.

Immediately after each drill, maneuver, or other formation, the wire cart will be thoroughly inspected by the chief of section. Notes will be made of necessary repairs, and turned in by him to the company commander. An inspection will be made prior to each formation by the chief of section, to see that all the bearings of the cart are clean and oiled, except the clutch, which will be bright and free from oil. He will see that the axles are greased and the harness in repair; that oil cans are full, and that there is no sediment in the holes to prevent the oil from reaching the bearings.

TO CLEAN THE WIRE CART

Always after the cart has been used, after each formation, before the cart is parked, the drivers and cart operators will thoroughly clean the chains, friction clutch, and sprocket wheels with a stiff brush and rough cloth, removing all dust, dirt, and hard oil. After cleaning, these parts will be gone over with a well-oiled cloth to prevent rust.

Once each week, or when directed by the company commander, the section will be assembled, and, under the supervision of the chief of section,

* The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

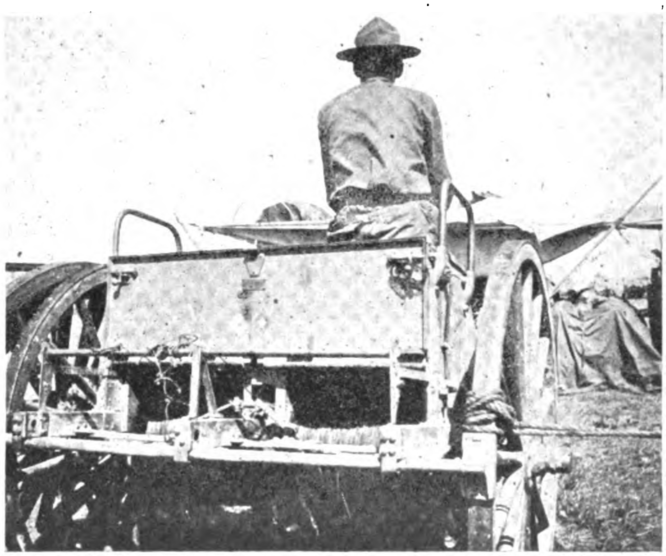
the cart given a thorough washing and cleaning throughout. All dirt and dust will be removed from the woodwork with a broom or stiff brush, and dust and oil from the metal parts with a cloth. Hose will then be used to wash the cart, if available; otherwise pails and sponges will be used. The metal parts will be wiped dry before oiling.

Occasionally the friction clutch will be taken apart under the supervision of the chief of section and cleaned with gasoline. A light oil will be sparingly used before assembling to prevent rust.

In the field paulins will be placed over the carts after use, and not removed until the cart is again used. These paulins will be folded and placed on the chest when the cart is in action.

Manipulation of the Wire Cart

The manipulation of the machinery of the cart for handling wire will be a part of the duty of the cart driver, unless an operator be placed on the



Rear view of the wire cart, care and manipulation of which is an important feature of Signal Corps instruction

cart, in which case the latter will do this. He will stop the cart at command or signal from the chief of section.

The reel will always be stopped before a march to the rear is taken up.

In spooling up wire the reel should be stopped when the loop gets too short and the clutch should be thrown in before the loop gets too long.

Laying the Lines

Slack will be pulled back and the wire tied in every 500 or 600 yards, or when the section chief directs. The line will always be tied at turns, in such manner as to prevent the wire from crossing the roads. Under no circumstances will the wire be so tied as to subtend the arc formed by any turn in the road. Should a number of turns come together, the cart will be halted until the work is satisfactorily performed. Ties will be made by two round turns and a half hitch, around bushes, trees, or anything fixed in the ground, and as close to the ground as possible.

At points where the line crosses roads or at crossroads the line will be raised overhead or buried, unless the road is little traveled, when it may be tied on each side with plenty of slack. When there is nothing to tie to, stones will be placed on the wire on either side of the road.

Generally the wire will be laid to one side of the roadbed to avoid

unnecessary damage to the wire from wheels, etc., but in unfenced country, where mounted men and stock may approach the road from the adjacent fields, it will frequently be advisable to lay it in the road, so that it will be flat and also be more easily seen.

Plenty of slack wire always will be taken, so that it will drop off the feet of animals passing over it, without breaking the wire or throwing the animal.

In crossing railroads or trolley lines, the wire is cut and the ends run under the rails. To prevent delay, a man of the section will be dropped off at such crossing and connect the wire, then overtake the section at an increased gait.

To repair a break the ends will be first scraped, the scraped ends tied in

Signal Corps men laying the lines in accordance with the regulations prescribed in the accompanying article

a square knot, the loose ends twisted around the line wire, and all carefully insulated with tape. The knots should be pulled tight and made as small as possible, so that in reeling up the knots will not jerk the pike and glove from the hand.

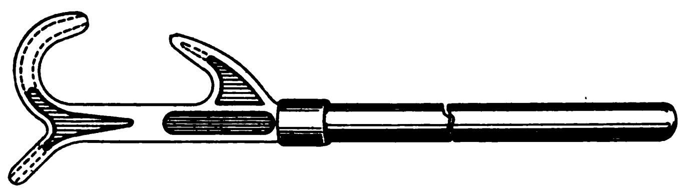
Lines which have been hastily laid will be patrolled at once, the linemen proceeding from each end until they meet, reporting from there by wire to their sections for instructions. In thus patrolling the lines it will be with a view to placing the wire flat on the ground, should it have become taut after the section passed, and otherwise arranging it to lessen the likelihood of breaks. Should a line cross a macadamized road, heavily traveled by artillery and cavalry, with no means to place it overhead, a lineman will be left at the point to repair any possible break. Should travel over the road practically cease, he will ask for instructions by wire.

Frequent patrols will be made over lines which pass over fields of grain, weeds, or underbrush in unfenced country, and can neither be placed flat on the ground nor overhead. Breaks are more apt to occur with lines thus laid.

On all occasions in handling wire, such as reeling it on to the reels in filling them or reeling it off for repairs, the section chief will have leaks in insulation repaired and all connections looked over. This aids materially in the working of the lines when the wire is laid.

Maneuvers of the Battalions

Wire will not be picked up at a faster gait than a trot. Should a more rapid gait become necessary to escape capture, the wire will be cut and abandoned. The real object is to lay wire and not to pick it up. Should wire have to be abandoned, the cart will refill its reel at the earliest possible moment from the reserve. Wire will only be temporarily abandoned at maneuvers. The section will return for it when the maneuver is completed. Under no circumstances will wire be reeled up on the reels or spools until any breaks in the metalic continuity of the wire have been repaired.



The wire pike used in laying field lines

In passing through villages, the wire will be placed overhead on telegraph and telephone poles. The climbers carried with the cart will be used for this purpose. A man will be dropped for this work; when completed, he overtakes the section. Men left behind in laying the wire, for any duty, will follow the line in overtaking the section, looking for breaks.

The gait to be taken in laying lines will depend on the kind of troops the section is following and the speed made by them. In all cases the line will keep in touch with the element it is to transmit information for. When the last station is cut in, horses may be unhitched if the troops seem likely to remain in place any length of time.

On the care with which lines are laid will depend in no small degree their efficiency. Carelessly laid lines will need much attention to repair breaks, and will cause many delays in messages, and no end of annoyance to other troops.

Speed will always be sacrificed to carefulness in this work. Wire fences, telephone and telegraph lines may sometimes be used to advantage.

Stations and Call Letters

Each section will be assigned call letters for four stations, which in general should not exceed four. The first section will be given the letters A, B, C, and D; the second section the letters F, G, H, and K; the third section M, N, Q, and R; the fourth section, S, U, W, and X. The stations are assigned to call letters in order of establishment, no location, beginning with the first letters. The call of headquarters is KO, which will be its call whenever it may be on the line, suspending for the time being the letter of the station where it may be. This applies to the first station established as well as to the later ones.

Branch lines electrically connected with the main line have offices given calls as if on the main line.

An office on a branch line not connected with the main line will be assigned the call letters of the station where the branch goes out, adding J to it.

As soon as a station is established the operator will call up the initial station and report. The opening of all stations, including the initial station, will be reported to the officer or non-commissioned officer in charge of the line, and by the latter to the company commander and to the commanding officer for whose use the line was established.

Each operator will have a personal sign, as Smith "SM," Johnson "JO," etc.

To open station with buzzer the operator will attach the buzzer connector to the line wire and ground rod. Care will be taken that the teeth of the connector have penetrated the insulation of the line wire. Damp ground will

A field wire station open and in operation under actual service conditions

be sought for the ground rod; if not available the ground will be dampened around it with water from the canteen.

The operators will not leave their buzzers unless properly relieved by higher authority.

At night, when lanterns are necessary at a station, the light must be so placed as to conceal it from hostile observation.

When it becomes necessary to move a station some distance from the line and it is not practicable to use field wire for extending the line, the buzzer carried by the lineman may be used.

The buzzer carried by the lineman may be used for opening stations on branch lines.

Stations will be conducted in a military manner. Silence will be preserved, except conversation relative to business. The lines will not be used for conversational purposes between operators.

Buzzers will be kept dry. In case of wet weather the shelter tents of messenger and operator will be made into an office.

No unauthorized person will be allowed around stations.

Maintaining the Lines

Each lineman will be equipped with a carrier with one-fourth mile buzzer wire and a buzzer for testing the line. This will enable linemen to determine in what part of the line a break may be. Intermediate stations will assist in this, and when the section in which the break exists has been located the messenger or any available man will be sent to find and repair it if no lineman is at hand. In following the line to locate breaks the lineman will take up the gallop, following the line with his eye where it is raised from the ground, and with the pike where it is on the ground. He picks it up with the hook. In order to prevent a knot or splice from being caught in the hook and jerking the pole from his hand he raises the pike in a horizontal position, slips the wire out of the hook and on to the handle, and allows the wire to run on it near the hook, the shoulder of the hook keeping it from slipping off. By lowering the pike and turning it around in the hand the wire slips quickly to the ground.

Signal Corps News

The War Department authorizes the following statement from the Land Division of the Signal Corps:

Technical Men Needed The demand for specialists in the American Army is increasing daily. Mechanics and technicians of every kind, including radio and buzzer operators, are needed by the Land Division of the Signal Corps.

Through the assistance of the Federal Board for Vocational Training, an opportunity is extended to men in the draft to perfect themselves in radio and buzzer work without expense, enabling them to select this branch of the service in the Signal Corps when they are called.

The Signal Corps has charge of all signaling and communication, including radio, telegraph, telephone, and cable service for the mobile Army, both at the immediate front and behind the lines. It is important and interesting work, since without this branch of the service the Army's "ears" would be stopped and in many instances its "eyes" would be valueless. Men who are expert telegraph and radio operators in civil life have an opportunity here to continue their specialty.

In nearly every large city the Federal Board, through local school authorities, has established schools of radio communication where all men of draft age who have not yet been called may receive a preliminary course in the operation of radio and buzzer instruments. There are now about 600 of these schools, where continuous instruction is given, usually during afternoons and evenings. It takes practically 200 hours for a student of average ability to attain a speed of 20 words per minute, sending and receiving.

If a student enrolled in one of these schools is ordered to report for military service by his local draft board before he has completed his course, he will be furnished with a proficiency card, stating the number of words he can send and receive. Upon the presentation of this card to the personnel officer at the mobilization camp to which he is sent he will be assigned to the Signal Corps.

If, after attaining a proficiency of 10 or more words per minute, a student decides that he desires to enter the service immediately, he may apply through the local school authorities to the Signal Corps for papers authorizing his individual induction into the service and his assignment to a radio school for advanced training.

The Signal Corps is particularly in need of highly trained technical personnel. Electrical engineers and men with a good fundamental training in engineering or physics will find excellent opportunities for service of a character which will permit them to make full use of their training and experience. Men of satisfactory qualifications are given three months' training in special Signal Corps schools operated under the supervision of the Land Division of the Signal Corps, and are given every opportunity to take examinations leading to promotion.

Men who have had experience as electrical repair men, wiremen, and mechanics are also desired for assignment to special schools and later to field organizations. Instruction of a high grade is given, and opportunity for promotion is excellent.

The following statement is authorized by the War Department:

Fitting Men to Army Units Latest figures show that nearly 240,000 transfers of men from one unit to another have taken place in Army camps in this country as a result of occupational qualifications ascertained through the committee on classification of personnel of The Adjutant General's office.

The speeding up of preparations for over-seas service during the past few weeks has meant a great increase in the work of the committee. About 40,000 transfers have taken place each week recently.

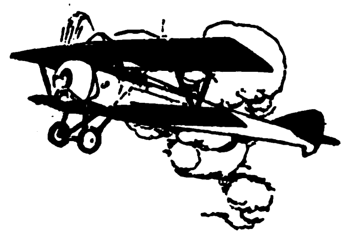
Through the medium of the committee an organization has been built up in all Army camps by which enlisted men and commissioned officers are classified according to occupational qualifications. In some of the camps, where as many as 2,500 men are received daily, a force of 200 trained interviewers is employed to ascertain full information regarding the men's occupations, education, experience, and special qualifications.

The central personnel bureau at Washington receives reports soon after the arrival at camp of each draft increment, showing the number of skilled and semi-skilled men in different occupations. The Signal Corps, Ordnance, Quartermaster, and other corps are constantly making requests for skilled men needed by their special troops. By means of the occupational classification the transfers are promptly made.

A general order which has just been issued requires that every enlisted man leaving this country shall have made out an occupational card. This enables officers on the other side to place men where they can be most useful.

How to Become an Aviator

The Thirteenth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Airplane Design, Power, Equipment and Military Tactics



By J. Andrew White
and Henry Woodhouse

BEGINNING consideration of actual flight, a preliminary survey of the aviator's equipment and aids is advisable. These consist of his clothing and accessories and the instruments which aid navigation of the air. Many arguments are advanced for the method of instruction by which the pilot acquires a sense of "feel" without dependence upon mechanical devices, but while this instinctive knowledge is essential, intelligent use of the instruments undoubtedly increases the aviator's efficiency.

Clothing—A warm coat is a necessity, for even in summer it is cold at high altitudes. In winter a fur lining is advisable; in ordinarily moderate weather the service uniform covered by a leather coat is sufficient. Pockets without flaps, closing by an elastic band, should be of generous size so that papers may be easily put away with one hand. Warm socks are essential and soft boots or puttees without straps should be worn with the riding breeches. Fleece-lined soft leather gauntlets, allowing easy freedom of fingers and wrists, are the proper protection for the hands. A padded helmet is a necessity. The aim in selecting clothing is to provide flexibility of movement and protection from the cold with the minimum of straps and strings to catch on the obstructions within the cockpit. Above all, clothing must be comfortable.

Goggles—As a protection from the wind, even though the airplane be provided with a wind shield, goggles should be used to take the strain off the eyes. Glass lenses should not be used; they should be made of colorless celluloid with a green shade at the top and bound by a stiff rubber rim shaped to conform to the face. A small piece of chamois should be carried to wipe off the flying oil.

Watch—An accurate timepiece with a wrist strap is essential to the military aviator.

Safety Belt—Under no circumstances should the aviator venture aloft without his safety belt adjusted. This device consists of a wide web of heavy webbing with a quick detachable locking device. The belt should be securely adjusted with the stress coming at the thighs.

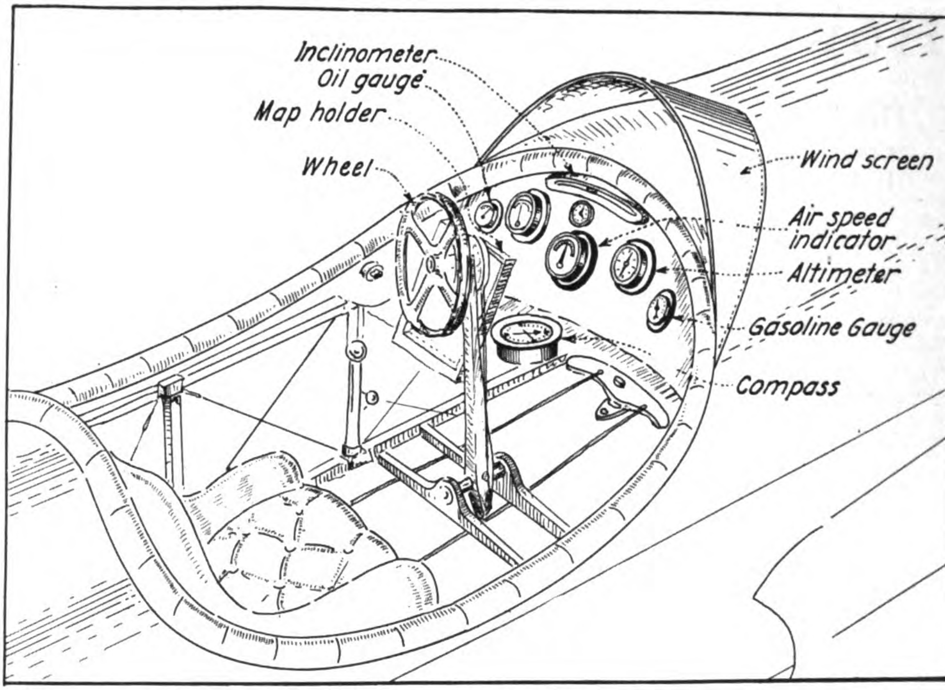


Figure 71—General view of a typical airplane cockpit

AIRPLANE INSTRUMENTS

SCOPE AND USEFULNESS

As with any class of travel, reaching the destination by air flight requires knowledge of position. The aviator obviously must also know the direction of his machine toward the horizontal. In or above the clouds, out of sight of earth, knowledge of these essentials must be gained through instruments. The devices required for air navigation must be compact and rugged, light, reliable and accurate.

GAUGES

An oil gauge definitely indicates the amount of oil in the crankcase, an oil-pressure gauge accurately indicating undisturbed flow and the pressure in the oil system. The gasoline gauge registers the quantity of gasoline available in the tanks, preferably by mechanical means.

LUMINOUS DIALS

Paints and compounds which illuminate pointers and figures on instrument dials are now in general use, electric lighting having been largely done away with because of the glare and the vibration to which lights are subjected. Zinc sulphide combined with radium are the main constituents of the most reliable luminous paints.

COCKPIT ARRANGEMENT

Wherever practicable, well upholstered seats are provided for aviators and in many cases comfort is further promoted by passing heated exhaust pipes through the cockpit. Figure 71 shows a typical arrangement of the pilot's seat and dash with air navigation instruments in position of easy visibility.

Figure 72—A military airplane compass

Figure 73—The barometer or altimeter

COMPASS

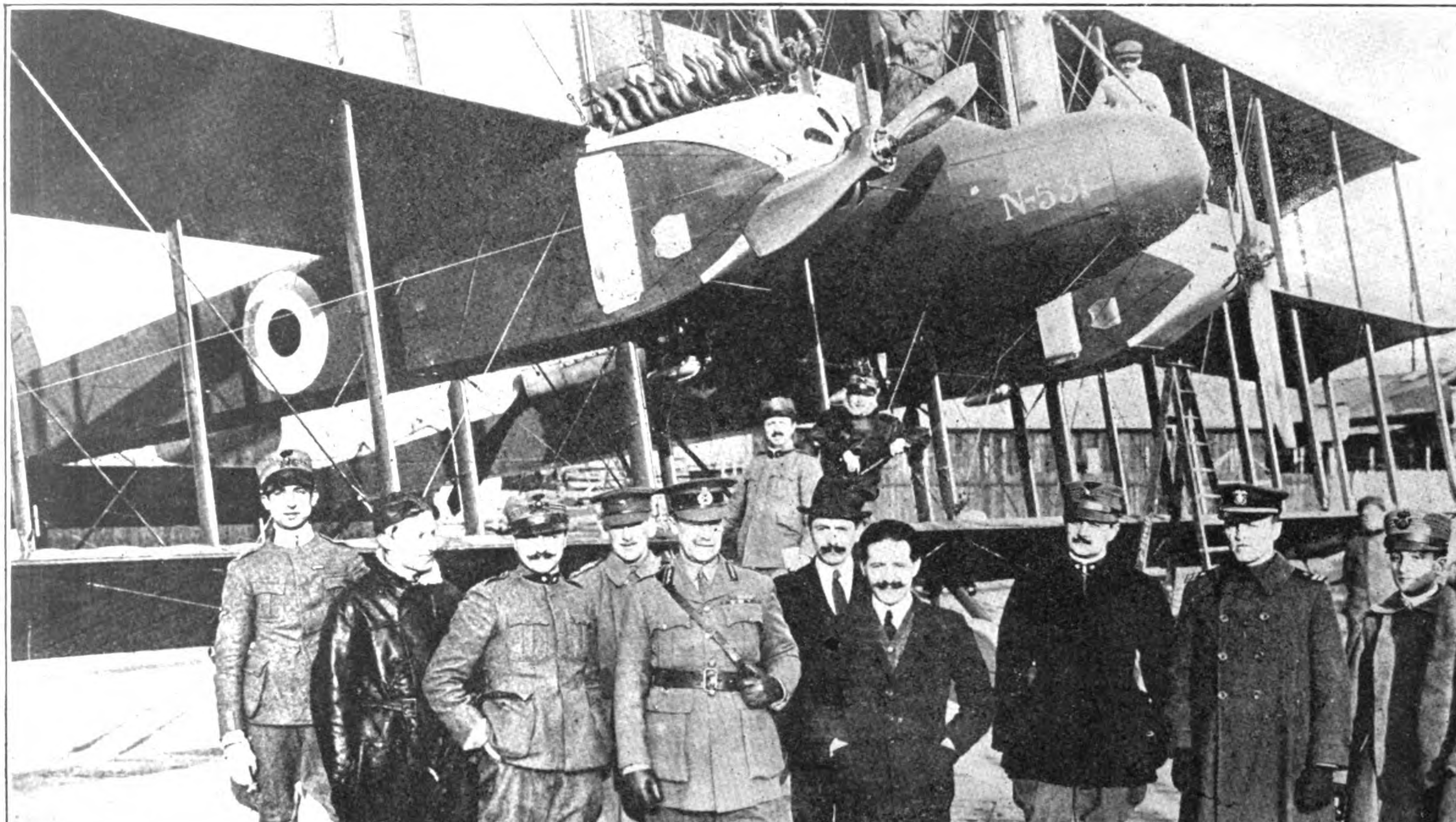
Air navigation, as well as sea, requires the aid of the compass, a device which contains a magnetic needle constantly pointing to the magnetic north. In the aviation compass illustrated in figure 72 a compensating attachment counteracts stray magnetic influences. The card, or graduated scale, floats in a mixture of alcohol contained in the inner bowl, the latter being bedded in horsehair, which absorbs vibration. The alcohol varies in proportion to water from 45 per cent to almost pure alcohol, the high percentage being maintained to prevent freezing at high altitudes.

BAROMETER OR ALTIMETER

To indicate the height of the airplane above the earth is the function of the instrument illustrated in figure 73. Essentially, it comprises a vacuum chamber which is acted upon by the varying density of the air. The dial is adjusted to zero on the ground. Location of the instrument on the airplane is of great importance by reason of the possibility of influence by velocity pressure.

TACHOMETER

This instrument, not illustrated, is in all essentials similar to the speedometer used for automobiles, except that it registers the number of revolutions of the motor. Its importance may be estimated by considering that the power delivered by the engine is directly related to its speed of revolution and that the speed of its turning may be used to compute the airplane's speed relative to the air. Tachometers are either magnetic or electric, the former type consisting of a magnet rotated by a flexible shaft coupled to the engine, and the latter comprising a generator, engine driven, electrically connected to an ammeter. With both type the indications are made by a needle and graduated arc on the dash.



(C) Press Ill. Svce.

The amazing development of aircraft is revealed in this photograph of the new Caproni triplane, features of which are the twin 12-cylinder motors and tractor screws with the addition of a pusher propeller behind the nacelle. The wireless generators are located on the struts just underneath the engine beds. In the center of the group are the Caproni brothers, builders of the leviathan of the air

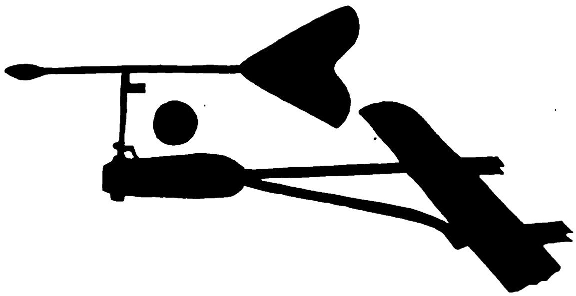


Figure 74—Angle of incidence indicator

Figure 75—An inclinometer

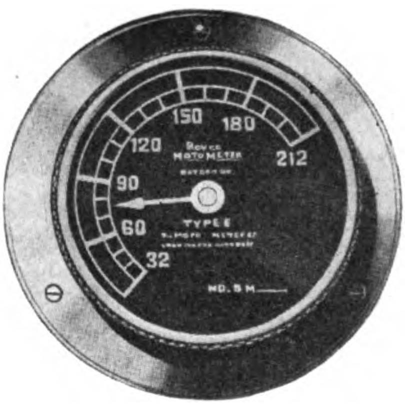


Figure 76—Engine temperature meter

ANGLE OF INCIDENCE INDICATOR

This device, illustrated in figure 74, is mounted on a forward strut clear of the influence of the propeller and the body. The vane, which remains level when the airplane is in motion, has a pointer and indicator graduated in degrees and visible to the aviator. The instrument shows the angle between the chord of the wings and the flight path. By means of a dry battery and electrical connections the round light bank shown is attached. When the flight is level no light shows. A white lamp signals when a dive is made at too steep an angle. A red light warns of an angle close to the stalling point. A green light indicates the best climbing angle.

INCLINOMETER

Two types of inclinometers are illustrated. The spirit-level type shown mounted on the dash in figure 71, is inaccurate in the presence of accelerations and has generally been superceded by the instrument illustrated in figure 75. This device registers the angle of the airplane with the horizontal, the scale being on a weighted wheel which is damped by floating in liquid, which insures sensitiveness and increases accuracy. The scale tips forward or backward with the angle of the airplane, the dial being mounted on the instrument board in the cockpit.

RADIATOR TEMPERATURE INDICATOR

The value of this device, illustrated in figure 76, is obvious when it is considered the great altitudes attained by airplanes and the necessity of knowing whether the motor is getting cold. Equally important is knowledge of imminent overheating. The instrument is, therefore designed to register from freezing to boiling.

Figure 78—Air speed meter

Figure 77—The drift meter

Figure 79—Banking indicator

DRIFT METER

The purpose of this instrument, shown in figure 77, is to enable the aviator to remain on a given course to his destination, irrespective of drift occasioned by side winds. The device comprises a telescope pointing vertically to the earth with hairs crossing the field of vision. A scale and pointer indicates the angle of drift in degrees and the compass lubber line moves automatically to correct for any existing drift. The instrument is widely used for cross-country flight.

AIR SPEED METER

This mechanism shows the airplane's rate of speed relative to the air. It serves to correct for the aviator any erroneous impressions which may be gained by his speed in relation to the ground, since that speed varies according to whether his airplane is flying with or into the wind. It is also useful to indicate excessive gliding speed, straightening out from which may stress the machine to dangerous limits. The principle of its operation is pressure of wind on a liquid contained in a tube, a lead from one end of which is open to the wind. This device is also known by the names, manometer and Pitot tube.

BANKING INDICATOR

The proper lateral attitude of flight is shown on this instrument by the airplane outline on a fixed dial, below which is a bar rotating from the center and controlled by a pendulum inside the case. When the indicator bar and the wing outline are parallel, as in the illustration, figure 79, the machine has the proper amount of bank. The pendulum swings outward in proportion to the radius and speed of the turn, and when the pilot has not properly banked his airplane the indicator bar will be out of parallel with the wing outline on the dial. The pilot then merely operates his controls in the indicated direction until the parallel is again registered. The instrument is of special value to the aviator at night or in a cloud or fog when human sensibilities are not dependable.

Figure 80—An airplane headed into the wind, the position for the start

Figure 81—Taxying at the start with wheels on the ground and tail raised

FIRST FLIGHTS

POSITION FOR THE START

The airplane should be turned directly against the wind, as this position aids the initial rise from the ground and makes it easier to maintain balance, a difficult matter in a cross wind.

LEAVING THE GROUND

The engine should be developing full power for the required thrust before the signal is given for the mechanicians to let go. As the airplane starts forward along the ground, the tail stabilizer is depressed by moving its control forward. This causes the tail to rise from the ground and places the lifting surface more horizontal, offering less resistance as rolling speed is acquired. Figure 81 illustrates this position. When the machine is taxying at a velocity equal or greater than the airplane's low flying speed, the tail control is pulled back gently and held. The tail end of the machine then drops and the angle of incidence of the wings is increased, causing the airplane to rise.

A minimum distance of 100 yards (covered in 5 to 10 seconds, according to the wind) is allowed between the starting point and the rise from the ground.

CLIMBING

The tail control is pulled back slightly and held fixed in the new position, further increasing the lifting surface angle of incidence. The motor is then accelerated to its proper climbing speed.

The airplane should be pointed into the wind for the first 200 feet of altitude and the student flier should rise at least 100 feet. A landing made from a lesser height is valueless for instruction purposes.

Aviation News

Navy Dept., Office of Naval Operations,
Washington, D. C.

Navy Flying Uniform

The following service flying uniform for officers detailed for aviation duty and officers of the Naval Reserve Flying Corps is prescribed. This uniform will also be worn by student officers with the exception as enumerated in paragraph under student officers. This cancels Changes in Uniform Regulations, U. S. Navy, 1913, Nos. 11, 12 and 14:

Winter Flight Service—Coat—To be of same pattern as white service coat, Uniform Regulations U. S. Navy, except that on the front there shall be four patch pockets of the same material as the coat, the two upper pockets being on the breast on each side, 7 inches deep and 6 inches wide, in side measurements, and vertically pleated down the center by a pleat 1½ inches wide, the top of these pockets being on a horizontal line 1 inch below the points of the shoulder; the upper pockets shall be closed by flaps of the same width as the pockets and 1⅛ inches deep at the ends, curving thence to a point in the center, where the depth shall be 3 inches; the two lower pockets are to be cut bellows style, 9 inches deep, 8⅛ inches wide at the top and 9⅛ inches wide at the bottom, inside measurements, the piece to form the bellows is to be 2⅛ inches wide, inside measurement, one edge to be seamed and stitched to the pocket, the other to be turned in and neatly stitched to the coat, the corners to be mitered so as to make the pocket lie close to the coat, the lower edges of the pocket and bellows piece to be rounded, these pockets to be sewed close to the bottom of the coat. There shall be a flap of two-ply cloth stitched 1 inch above each lower pocket opening 3⅛ inches wide at the point in the center and curving to 1⅛ inches wide at each side; there shall be a button hole worked vertically in the point of the flap, the flap to be stitched to the coat on a horizontal line with the bottom button. Extending from the neck at the front of the coat on each side to the top of each upper pocket there shall be two welted gore seams about 1⅛ inches apart at the collar and 2 inches apart at the top of the pocket. Inside pockets may be added if desired. Material to be of forestry green as prescribed in Uniform Regulations, U. S. Marine Corps, for winter field service.

Breeches—To be of same pattern as winter field breeches, Uniform Regulations, U. S. Marine Corps. Material to be of forestry green.

Trousers—To be of same pattern as undress trousers, Uniform Regulations, U. S. Navy. Material to be of forestry green. To be worn when leggings are not worn.

Major John Purroy Mitchel, former Mayor of New York, recently killed in an airplane accident

Overcoat—To be of same pattern as the Uniform Overcoat Regulations, U. S. Navy. Material will be of forestry green. Shall be knee length and shall have five plain, brown buttons, 1⅛ inches in diameter, on each front. Lower buttons placed about three inches below the sword belt, the other equally spaced up to the throat. Sleeve stripes shall be brown.

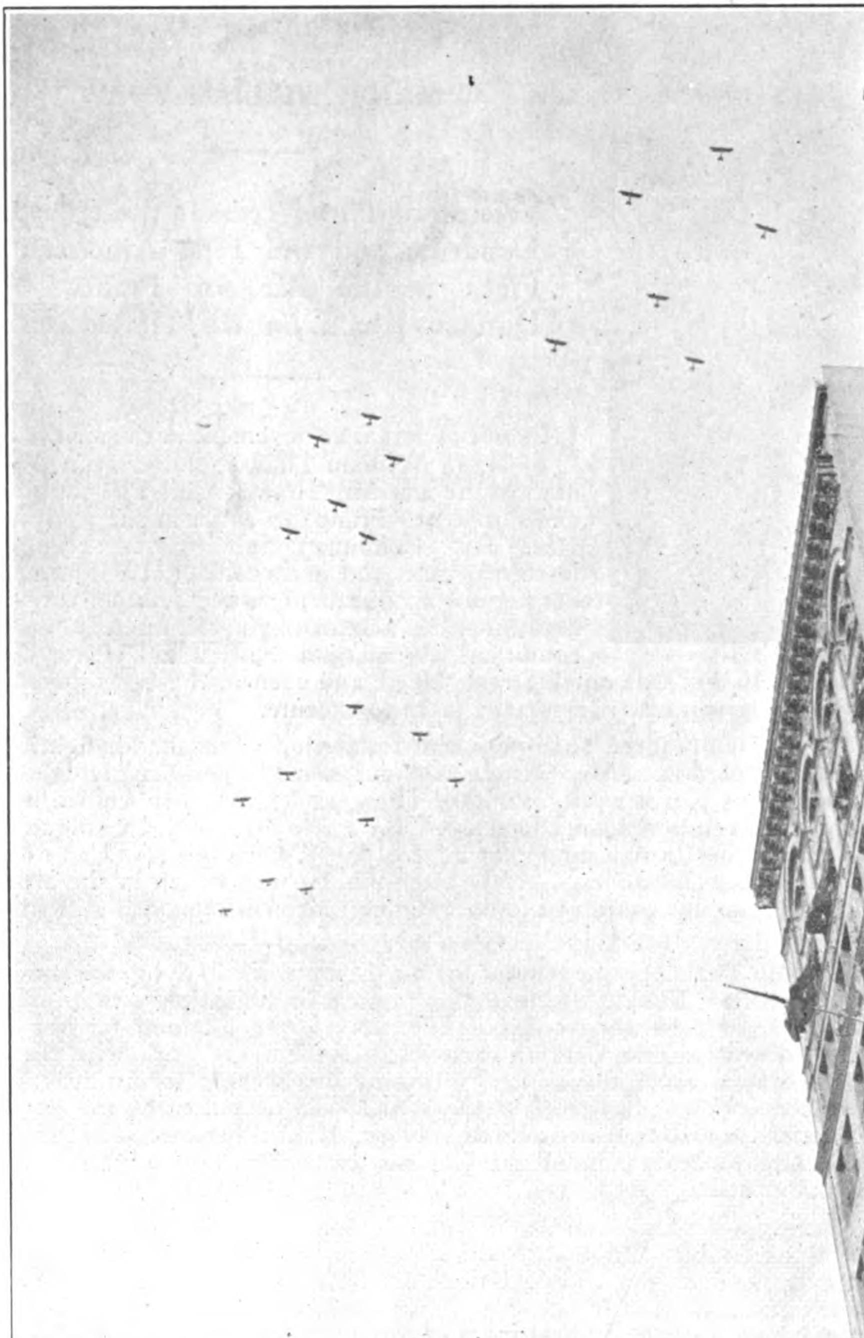
Gloves—Brown.

Caps—Similar to service blue caps, Uniform Regulations, U. S. Navy, except that top will be of forestry green material.

Shoes—High laced shoes of tan leather.

Leggings—To be of tan leather and of the pattern known as "puttee."

Flannel Shirts—Similar to flannel shirts, Marine Corps Regulations.



(C) Int. Film Svce.

In the July 4th celebration New York centered its activities in a monster parade. As the procession passed along Fifth Avenue American military airplanes appeared in flying formation to accompany the column. This view shows 21 American made airplanes over the city

MILITARY AIRMEN

MAJOR WILLIAM THAW

Veteran of Three Years in the Lafayette Escadrille and the First American to Fight in the Air for France Has Donned Khaki for the United States.

IN point of actual achievement in the air the record of Major William Thaw is unique. In the early days of the war Mr. Thaw left his Pittsburgh home and hurried to France to enlist in the aviation service. His preliminary training was accomplished in record time, and in December, 1914, he received his regular appointment to the aviation corps. The first American aviator to go aloft under actual battle conditions abroad, and the first to fly over German territory, his skill was quickly recognized, and even in the early days of the war he was given many important tasks to execute.

At his own request Thaw was sent to Verdun when the air fighting was particularly perilous. Here he carried out many orders involving difficult and dangerous patrol work. Captain Thaw, as he was then known, flew an average of seven hours daily for eleven days. He established a unique record for participating in five air fights in two days. On the second day he shot down a German machine. Shortly after this he was struck in the arm by a German bullet, but continued to fly, although his arm remained stiff from the wound.

Captain Thaw became famous for his daring work in flying for the Lafayette Escadrille. During the time this famous organization was in existence Captain Thaw flew thousands of kilometers over German territory. He brought down his first German early in 1916. For his work with the Escadrille he was awarded the Military Cross by the French Government; among other decorations he has received the War Medal presented by the Aero Club of America for distinguished acts of bravery. His brilliant work in the air also caused him to be appointed chief of the escadrille, the only American to hold this post.

During a visit to America in 1916, Major, then Lieutenant, Thaw took part in the famous "Football Special," which was the first long flight of its kind ever made in the United States. A fleet of twelve passenger-carrying airplanes went aloft at Mineola, and after picking up two more craft at Governors Island, flew to Princeton, N. J., to attend a football game. All the fliers arrived in time for the game and afterwards returned without mishap to New York.

Following America's entrance into the war, when the Lafayette Escadrille was disbanded, he donned the uniform of a Major of our army and has since, under the American flag, waged many successful battles in the air.

Visual Signaling for the Army

The Superiority of Signal Disks Over Semaphore Flags in Code Signaling is Demonstrated

By Lieut. Col. B. O. Lenoir,
Signal Corps, U. S. A.

Signaling machine

SOME interesting experiments in signaling have been made by the writer comparing the relative efficiency of the semaphore flags with the different sizes of very light disks, using the International code. The American Morse code can be used equally as well.

Four different sized disks, 6, 8, 10 and 12 inches in diameter were constructed of small wire. A very light wooden rod from 20 to 30 inches long, ¼-inch thick, ⅞-inch wide at the handle, tapering to ½-inch at the top, was rigidly fastened to the disk by twine, the wooden handle reaching through the wire circle to give it the rigidity which is essential for rapid signaling. Black cloth covered one side of the disk, with white cloth on the reverse side; the white side being used against dark backgrounds and the black side against the light backgrounds.

When the machine is in operation the edge of the disk cuts the air with practically no friction. No front motion is used, only the time spacing as used in American Morse telegraphy is required. The disks weigh from 1½ to 2 ounces, and can easily be operated with one hand, using the telegraphers' combined wrist and arm motion. It is necessary that the disks be rigid, for rapid sending.

With either the American or International Morse code over the short or long distances, the speed is as great as the semaphore, while many men can use the disks more rapidly. Being always extended, they are more easily seen than the semaphore. There is only one disk to operate, as against the two flags of the semaphore. In fast sending with flags the liability of error is greater for some difficulty is encountered in forming the angles properly.

With the 6-inch disk, 15 to 30 words of five letters each can be transmitted clearly for short distances, and with the precision of the telegraph which it resembles.

With the 8-inch disk, good readable signals can be read at 2,000 feet. At this distance, the semaphore is not reliably read owing to the difficulty of keeping the flags extended all the time. With the 10-inch disk, much better signals can be made and read at 2,000 feet, and with the 12-inch disk there is a still greater improvement in visibility. In these tests it was found that glasses are not needed.

It is thought that at 2,000 feet the 8-inch disk is slightly superior to the semaphore and on the principle of the larger the disk, the better the visibility, the 10- and 12-inch disk is far superior.

The superiority of the disk over the semaphore pertains both to visibility and rapidity at 2,000 feet. Twelve to eighteen words of five letters each can be easily read with the naked eye when the disks are used, while the semaphore cannot be seen all the time with the naked eye, owing to the fact that the flags are not fully extended, and again to the fact that the mixture of colors tends toward camouflage. A greater speed than 15 words per minute requires considerable expertness in either code.

Many letters have been received, showing that the writers have used the signal disks with advantage over the semaphore as to speed and visibility. The abolition of the semaphore entirely would simplify signaling in that it would reduce by one language the number of signal languages to be learned intuitively. The term "intuitively" is used, for rapid signaling requires practice so long that sending and receiving are done by intuition. There is no time to think or reason—those who have to think are not experts. Men who can handle only 8 or 10 words per minute cannot be considered expert signalists. There is no short route to the expert grade; it requires practice over a long period of time.

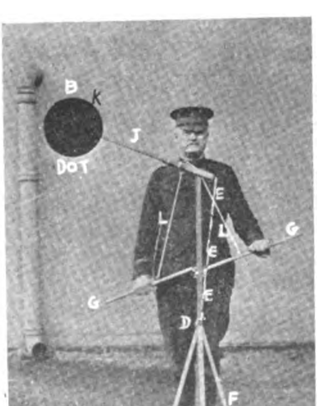
The writer has constructed a sending machine, shown in the accompanying illustration, using large disks at a long distance and operated something like a telegraph key. This machine lessens the labor of sending, for when 100 words or more are sent rapidly with large disks it is tiresome to the sender. The machine is simple and can be easily made. The weight of the whole apparatus including the disk, as used in Seattle, is a little less than 5 lbs. A diagram will be sent to those interested.

Success has also been attained in using only dots and dashes, as in telegraphy, using the disk either by hand or on the sending machine.

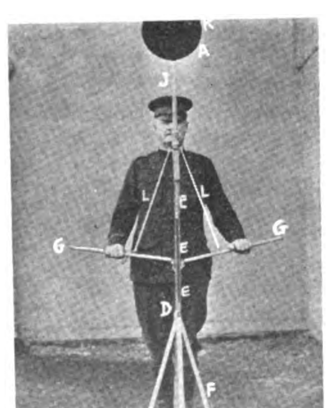
Fifteen words a minute can be sent, which is not more rapid than sending by hand, but there is less fatigue. In addition, the movement of the disk is more regular; in sending by hand the movement on the left side sometimes is not enough for the disk to entirely clear the body unless special care is taken.

By having the apparatus made longer, possibly up to a height of 50 feet or more, it could be operated from the bottom of a trench, the disk being at any elevation that may be desired above the trench.

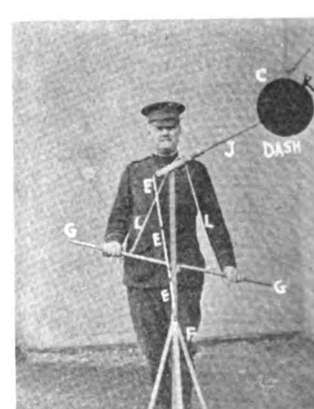
It is requested that those signalists who try the disks for signaling, send their experiences to the writer.



Position of disk to indicate dot



Normal position of disk



Position of disk to indicate dash

High Power Stations

Some Features of the Long Distance Stations of the American Marconi Company

By C. H. Taylor

Engineer, Transoceanic Division, Marconi Wireless Telegraph Co.

(*Continued from July Wireless Age.*)

The chief source of trouble to the commercial operation of long distance stations is the volume and the intensity of the atmospheric disturbances which are always present on the longer wave-lengths. These were found to be

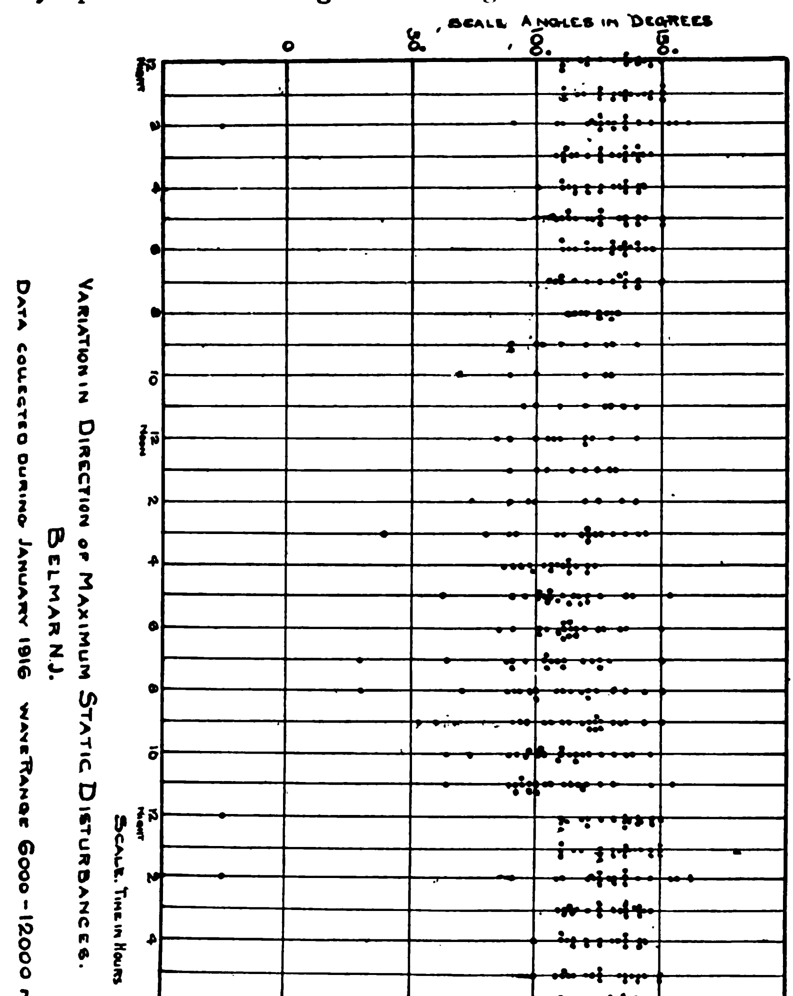


Figure 8—Radio-goniometer tests

exceptionally severe on the long waves proposed to be used at these stations—namely, 6,000 to 16,000 metres, and it was at once realised that the usefulness of these stations for commercial business would depend to a great extent upon the ability to eliminate or minimise the trouble from this source. As stated above, experiments with the antenna did not appear to be the correct line of attack, since the sturb and the signal were diminished in about the same

proportion, yet there is some advantage to be gained from this, since anything that decreases the continuous load on the detector must be of service.

One of the first questions that naturally arises in connection with these sturbs is "Where do they come from?" and it was considered that if their "office of origin" could be located this might help solve the problem of their elimination. For this purpose an investigation has been conducted at the Belmar station, where a directive antenna of the Bellini-Tosi type was erected. A receiving set with a radiogoniometer circuit was installed and continuous watch was kept throughout the last months of 1915 and the early months of 1916. An hourly record of the apparent direction of the maximum sturbs was kept during that period. The antenna was adjusted so that its zero line was 28° 14′ East of North; the zero reading being on the East and the 180 on the West end of the line. The results are shown on the various charts (*See figures 7 and 8*).

At first sight, the results for our first month of this work was not very promising—this is the chart for part of September and all of October—but it will be seen that the greater number of readings showed that the sturbs were travelling past the station in some definite direction. By the help of the daily variation curves it can be seen that the bulk of these sturbs are moving in a direction embraced by the angular range of 90-130, and that outside this range there is another lighter group with an angular range of 50-70, and the other directive readings are scattered around as would be expected. It may also be remarked that the readings showing lack of directivity are more frequent in the first chart than in any of the subsequent ones.

These observations were carried out on a wave-length group from 5,500 to 12,000 meters, and the Arlington 10 p. m. time-and-weather-signals formed the subject thereof. Although it was usual to find no marked alteration in the directivity of the maximum sturb when a wave change was made, yet this is by no means invariably so. This change in the directivity was most marked when swinging from the shorter group of waves to the longest. For instance, a reading on 5,500 gave the angle as 93 and an immediate change to 9,500 gave 120. It was noticed that the shorter wave-lengths favoured the 50-70 region of sturbs. It was also shown that occasions when there were more than one maximum are not infrequent.

At the same time as the noisiest position was being noted, a record of the least noisy was made. This minimum was sometimes rather hard to locate, showing the presence of sturbs travelling in more than one direction even when there was no observable double maxima. The minimum was seldom strictly 90 degrees from the maximum angle, but rarely deviated far from it. In general it seemed to be slightly less than 90 degrees. When more than one minimum is observed, and no double maxima, it was usually found that the maximum was very broad, even when the two minima were each quite sharply defined. It was, however, more usual to have an ill-defined minimum even when the maximum was sharp. The changes in the directivity of the maximum sturb were sometimes sharp enough to follow during the hour; for instance, on October 15th, at 10 p. m., the maximum was at 120; fifteen minutes later it had increased to 122; another ten minutes and it had climbed to 128; after which it fell off and had diminished to 117 by the end of the next fifteen minutes, and continued to decrease, reaching 114 ten minutes later and 110 at 11 p. m.

From these observations we should gather that the bulk of the sturbs at Belmar are due to disturbances travelling by the station in a direction approximately 90 degrees from the zero line, and that there is a secondary source travelling in a direction averaging 60 degrees from the zero line. This latter source appears to be less evident during the winter months.

It would therefore appear that the major portion of the sturbs at Belmar are travelling in a direction that may be roughly designated as across the line of the coast.

At the same time as these observations were being made, record was kept of the goniometer angle at which several of the long distance stations gave max-

(C) Int. Film Svce.

When a German submarine overhauled the Carolina on June 2nd orders were shouted by megaphone to the young man pictured above to stop sending the distress call. Though shells were already bursting about the wireless cabin this New York boy replied that he wasn't taking orders from any skipper but his own and he didn't stop shooting out the SOS until his own Captain came to the radio room and told him to stop. Meanwhile he had received an answer from Cape May station. This plucky American is Erwin W. Vogel, eighteen years old, a former amateur who graduated from the Marconi Institute two years ago

imum audibility and it was found that there was a discrepancy between the true directivity and the apparent directivity of their waves as they passed this station. These results are set out chiefly because of its bearing on the true direction of the sturbs and they must not be accepted as final until further confirmation has been made both at this point, and, if possible, at others. (*See figure* 8.)

At Belmar the deviation between the true direction of a long distance station and the goniometer angle of the direction of its radiated waves as they travel by that station is sometimes considerable. This variation appears to depend, to some extent, upon the electrical clarity of the atmosphere. For instance, when the signals from Glace Bay station are at their normal or above their normal strength their apparent direction lies close to the average of a number of observations around the true direction; but if they are much below their normal strength then the deviation may be large, both from the true and the average directions.

Unfortunately there are few stations to the west of Belmar upon which a series of daily observations could be made, and there is thus a very big gap in these records.

No especial variation was noticed during the sunrise and sunset periods beyond that already recorded for periods of weak signals at other times during the day. And it is curious to note that the directivity of the Arlington wave was furthest from the true bearing of that station on a night when a tropical storm warning was broadcasted.

So far as can be seen, a change of wave length at the transmitting station does not affect this deviation except in the event of the received signal being weakened below normal.

No observations of this nature have been taken on the Pacific coast so far as I am aware, and a series of these should be made both for that coast and for an isolated spot like Honolulu.

It is quite frequently found at the stations at Honolulu that there is a certain wave-length selectivity to the sturb. When the short wave stations are being bothered very badly the long wave stations may be reporting this trouble normal or even below normal. During the local storm season this sturb trouble is heavy on the long waves and varies with the storms. So long as the trade winds blow and the atmospheric conditions are unchanged there is a marked absence of this type of trouble. But while there is a daily change in the weather conditions the sturbs are present in great force just as they are on the coast.

At the Marshall station in California, trouble from sturbs is heavy throughout the summer months and gets lighter during the winter. During the heavy wind storms which are quite common during the spring at this station there seemed to be some relation between the intensity of the sturb and the barometer reading. During very heavy gales when the wind was varying in velocity very rapidly the strength of the signals and of the sturbs appeared to follow the fluctuations of the barometer. On one occasion the barometer needle was oscillating between 29.44 and 29.52 at a rate of about 10 cycles per minute. When the wind increased suddenly in velocity, the barometer fell and the strength of the sturbs and of the signals decreased in strength to a remarkable degree, and returned to normal as soon as the gust passed. This phenomenon recurred with several of the wind storms when the local weather bureau reported a wind velocity between 90 and 100 miles per hour, and the wind was very gusty. During the summer months observations on the movements of the barometer needle and the prevalence of sturbs were made but definite relation could not be established.

The effect of the humidity was also noted, but here again the results were disappointing. Without doubt a much more extended series of observations must be made upon both of these points.

Interference is another problem that has already assumed nearly as much importance as that of the sturbs and will undoubtedly increase in importance as the number of stations radiating energy in any considerable quantity is increased in any area. If the receiving circuit is one that can be readily set into vibration, then

it will be impulsed by waves of very different lengths and the detector circuit may respond. The problem would be more simple if (*a*) all these signals were of the same order of loudness when the circuits are in resonance with their wave-lengths, if (*b*) they all had the same shape of wave-train, and if (*c*) their wave-lengths were not all packed closely together. Unfortunately the interference that is the cause of most of the trouble usually comes from nearby power stations employing considerable power a few miles off and working on a wave-length that

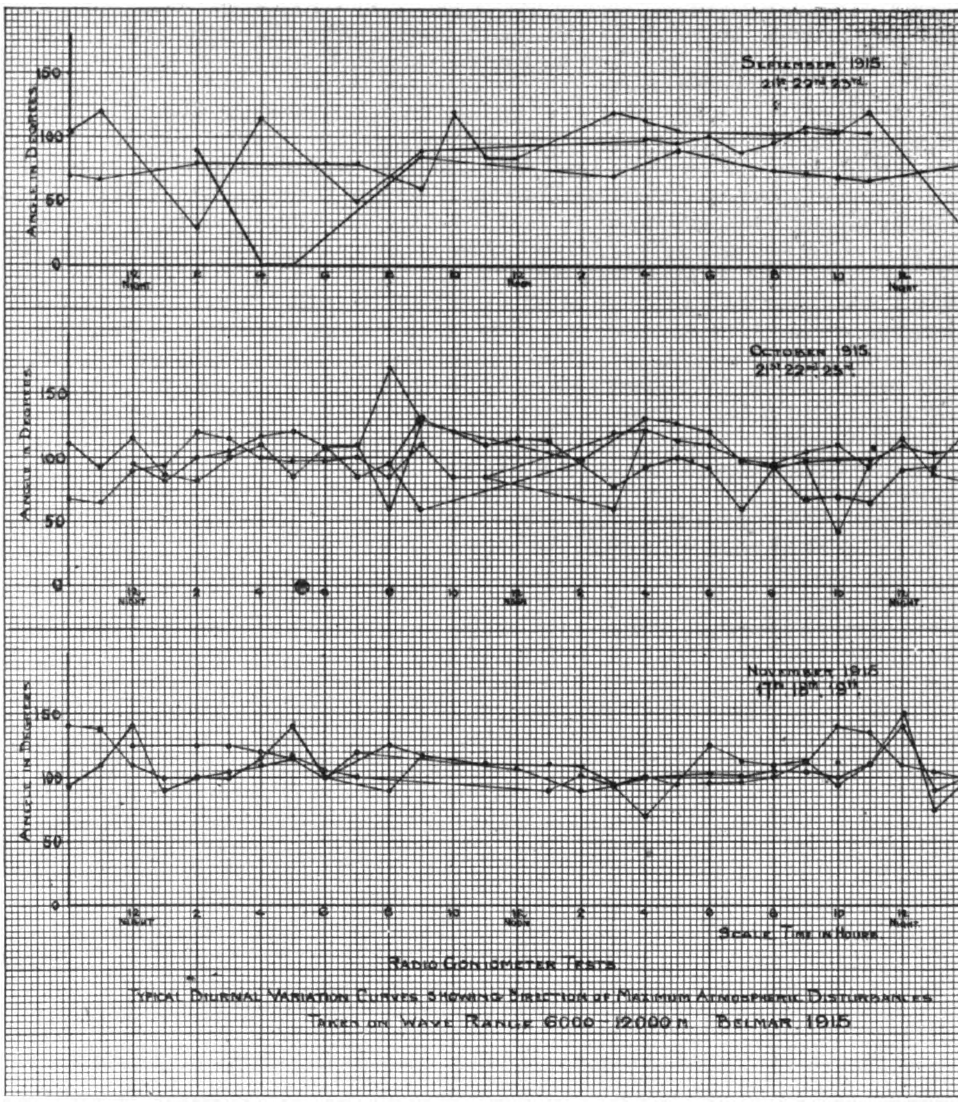


Figure 9—Typical diurnal variation curves showing direction of maximum atmospheric disturbances

is not very different from that being used by the station about 2 or 3,000 miles off, the signals of which are to be copied.

There is a wide difference in minimising interference from a nearby spark and a nearby arc station. In all modern spark stations the emitted wave trains produce a more or less clear musical tone in the telephones of the receiver. Change of wave length is not indulged in by commercial spark stations to any marked extent, so adjustments can be made and set up to remain indefinitely.

But with a local arc station one has much more trouble to guard against. In addition to the working wave there is also the compensating wave and the noises of the arc. The compensating wave area sometimes seems to be unnecessarily broad, and if it is close to the transmitting wave the two may overlap and make a very broad disturbance area. As a sample of these wave areas the following taken in November last may be cited. (*See figure* 9.) The audibility throughout these areas was 20 plus. The tuning condenser ranges were for the lower group from 10 to 42 and for the upper group from 60 to 96; the total range of the condenser is 0 to 180. The wave-lengths corresponding to these adjustments were 5,000 to 7,870 and 8,980 to 10,990 meters. Frequent wave changes make it difficult to adequately protect a circuit, but these frequent changes are of extreme use to one who is watching out for opportunities for the study of this problem.

The effect of the arc-upon-spark signals varies with the difference in length between the two waves. If identical or closely similar, there is a smothering effect upon the distant spark station's signals if these are quite weak; in the worst cases the spark signals cannot be heard through the arc noises. If the two wave lengths are near to one another most pronounced beats will be heard; the spark appears to throb, a result that makes the signal rather difficult to read. A distant arc, one the operations of which are not particularly noticeable in the receiver, will also cause this throbbing, and in such cases there is no audible evidence of the arc yet the signal seems to fade and grow as would be the case if there were a swinging fault on the line. In both of these cases the spark signals can be read, even if the incoming signal is relatively weak. At other wave-lengths the arc will heterodyne the spark signal and improve its audibility in the well-known manner due to this method of reception. Unfortunately, the arc station would not maintain this wave-length and assist the spark work as often as could be desired.

In a general way, it seems better to overcome the interference from this source by tone working, as the musical note is more readily followed through the arc noises than the tones derived by the heterodyne method of reception. But there are many occasions in which the ability to alter the pitch of the signal more than compensated for the other defects of this method, and the increase in the audibility of the signals assisted the operator.

Working on long waves has demonstrated that stations at a moderate distance can impulse these receivers in a troublesome manner if they—the distant station—are being operated upon a wave that is a submultiple of the wave for which the receiver is tuned. It has also been noted that this trouble increases if the long wave is some even multiple of the shorter one. On one occasion it was found that a certain station was quite troublesome from time to time although it was at a moderate distance away, and on other occasions it was scarcely audible. So far as could be ascertained no changes were being made at that station. But wave-length changes were being made at the Marconi stations, and it was soon evident that the interference was most troublesome when these were tuned to a wave length that was an even multiple of the wave-length of the disturbing stations, and was less troublesome when the received wave was either an odd multiple or not strictly related to their wave.

Advantage was taken of this feature in some work on the minimisation of these and sturb troubles. The antenna circuit may be tuned to a multiple of the wave length to be received and the secondary circuit set at the correct wave length; then it will be found that the troubles from sturbs fall off at a greater rate than does the strength of the signal. In this case amplification can be resorted to with advantage.

An alternative method is one in which the antenna is made to be less readily impulsed, a procedure that decreases its receptivity, and the gain in its relative freedom from the above troubles may be utilised by the amplification of the incoming signal above that which is possible on circuits that are crowded with sturbs.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By Captain Fritz E. Uttmark

ERRATA

Errors will occur in the process of turning manuscript into printing. The following introductory paragraph was omitted on page 837, July Wireless Age:

"Before proceeding further it will be of interest to record a few facts about the earth. We introduce a chapter taken from Young's 'Astronomy.' This work is by one of my favorite authors on the subject."

CHAPTER VIII.

Day's Work (*Continued from June Wireless Age*)

Example for Practice

	Compass Course	Wind	Leeway	Deviation	Variation
1.	N W	N N E	1 pt.	½ pt. E	½ pt. W
2.	E N E	North	2 pt.	½ pt. E	½ pt. W
3.	N W ½ W	N N E	½ pt.	¼ pt. W	½ pt. W
4.	South	W S W	¾ pt.	¼ pt. W	1 pt. W
5.	N 30° E	E S E	10°	5° W	10° E
6.	310°		15°	12° E	3° W

Answer

No. 1	N W by W	No. 4	S S E
No. 2	East	No. 5	N 5° E
No. 3	W N W	No. 6	333°

Explanation of Tables I and II Bowditch

Table I contains the Difference of Latitude and Departure corresponding to distances not exceeding 300 miles and for courses to every ¼ point of the compass.

Table II is of the same nature but for courses consisting of all degrees and including distances up to 600 miles.

In Table I all courses from ¼ point up to 4 points are found and taken out from the top of the page. For courses from 4 points up to 7¾ are taken out from the bottom of the page.

In Table II courses from 1° to 45° are found and taken out from the top of the page and courses from 45° to 89° are found and taken out from the bottom of the page. Note that the latitude and departure columns are reversed when looking from the bottom of the page. For full explanation of the tables see plane sailing, Middle Latitude Sailing and Mercator Sailing (see previous chapter). The Tables I and II Bowditch may be employed in solving all the problems relating to right triangles.

Dead Reckoning (Day's Work)

Example. From latitude 39° 40′ 50″ N and longitude 72° 40′ 30″ W a vessel sails the following courses and distances:

Compass Course	Tack	Leeway	Deviation	Variation	Distance
S S E	S.T.	½ pt.	0	½ pt. W	35
S by E ½ E	S.T.	½ pt.	0	½ pt. W	40
S by E ¾ E	S.T.	½ pt.	½ pt. W	½ pt. W	25
S S E ¼ E	S.T.	¾ pt.	¾ pt. W	¾ pt. W	20

Required latitude and longitude by D. R., also course and distance made good.

Solution

Compass Course	Tack	Leeway	Deviation	Var.	Error	True Course	Dist.	Diff.L. S.	Dp. E.
S S E	St.	½ pt. W	0	½ pt. W	1 pt. W	S E by S	35	29.1	19.4
S by E ½ E	St.	½ pt. W	0	½ pt. W	1 pt. W	S S E ½ E	40	35.3	18.9
S by E ¾ E	St.	½ pt. W	½ pt. W	½ pt. W	1½ pt. W	S E ¾ S	25	20.1	14.9
S S E ¼ E	St.	¾ pt. W	¾ pt. W	¾ pt. W	2¼ pt. W	S E ½ E	20	12.7	15.5
								97.2S	68.7E

Latitude Left	39°	40′	50″	N
Difference of Latitude .	1	37	12	S
Latitude by Dead Reckoning	38°	3′	38″	N
Latitude Left	39°	40′	50″	N
Latitude by Dead Reckoning	38	3	38	
Divided by ..2.........	77°	44′	28″	
Gives Middle Latitude ..	38°	52′	(39°)	

Longitude Left	72°	40′	30″	W
Difference of Longitude	1	28	00	E
Longitude by Dead Reckoning	71°	12′	30″	W

Course Made Good ....S 35° E
Distance Made Good ....119 miles

From latitude 30° 20′ 40″ North and longitude 67° 43′ 57″ West, a ship sailed N 5° W by compass. Distance 180 miles. Variation 4° West. Deviation 7° East.

For 10 hours the ship was in a current flowing N 45° E (magnetic) at the rate of 2 miles per hour. Variation of compass 5° West.

For 6 hours ship was hove-to on the starboard tack, ship's head coming up to East and falling off to N 68° E. Leeway 20°. Variation 6° W. Deviation 4° West. Ship forged ahead at the rate of 1½ knots per hour.

Required latitude and longitude of the ship, also true course and distance made good.

Solution

Compass Course	Tack	Leeway	Deviation	Var.	Error	True Course	Distance	Diff.L. N	Depar. E	Depar. W
N 5° W			4° W	7° E	3° E	N 2° W	180	179.9		6.3
N 45° E			5° W	0	5° W	N 40° E	20	15.3	12.9	
N 79° E	St.	20° W	6° W	4° W	30° W	N 49° E	9	5.9	6.8	
								201.1N	19.7	6.3
									6.3	
									13.4E	

Latitude Left	30°	40′	20″	N
Difference of Latitude..	3	21	6	
Latitude by Dead Reckoning	33°	41′	46″	N
Latitude Left	30°	20′	40″	N
Latitude by Dead Reckoning	33	41	46	
Divided by 2	64°	62′	26″	
Gives Middle Latitude..	31°	1′	13″	W

Longitude Left	67°	43′	57″	W
Difference of Longitude		16′	00″	E
Longitude by Dead Reckoning	67°	27′	57″	W

Course Made Good .... N 4° E
Distance Made Good..........202 miles

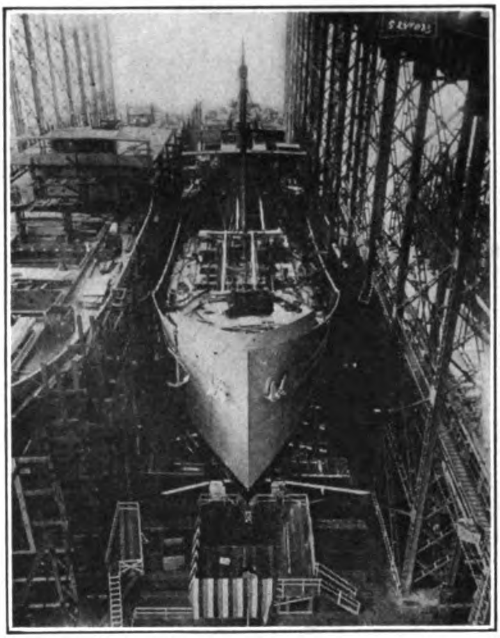
(To be continued.)

Navigation News

News of the safe arrival in France a few weeks ago of 16 German ships, seized in American waters shortly after the declaration of war by the United States, caused officials of the Morse Dry Dock & Repair Company, Brooklyn, a thrill of pleasure, owing to the fact that several of the vessels were restored to usefulness by the Morse Company after their machinery had been damaged by the German crews to put the ships out of commission.

Seized German Ships Improved

The German scheme of ruin was shrewdly devised and arranged, from plugging the steam pipes to the burning up of boilers by dry firing.



Collier Tuckahoe built in 27 days, being a world record for speedy ship construction

Patching and welding was determined upon as the method of repairing the damage, and the last of the fleet was finished ready to be ordered into service, as a Thanksgiving gift to the nation. Three methods of patching the broken marine engines were used: electric welding, oxy-acetylene welding and ordinary mechanical patching. In no case were repairs to the propulsive machinery delayed beyond the time necessary to equip the vessels as transports, in which service they are being used. The most important ships handled by the Morse Company were the "Koenig Wilhelm II" and the "Gosser-Kurfurst."

❧ ❧ ❧

Five yards for the building of concrete ships and the construction of a total of 42 new concrete ships have been authorized by the United States Shipping Board.

Forty-two New Concrete Ships

Of these 42 concrete ships, contracts for 18 already have been given by the Emergency Fleet Corporation. Contracts for the building of the remainder will be let shortly. These 42 concrete ships nearly all will be tankers, of 7,500 tons each, with a capacity of 50,000 barrels of oil. Each of the 7,500-ton ships will have 2,800 horse power. Others of the concrete ships are cargo ships, of 3,000 and 3,500 tons. The 42 concrete ships will have a total of 298,500 dead-weight tonnage.

The five Government yards will be located at various points on our coasts. Construction of one of these yards at Wilmington, N. C., is already under way. Others will be at Jacksonville, Fla., Mobile, Ala., and San Diego, Cal. The fifth yard is that at San Francisco, of the San Francisco Shipbuilding Company, which built the "Faith," the first concrete vessel. This company has been given an agency contract for eight concrete ships. There are also two private concrete shipbuilding yards, one at Brunswick, Ga., the other at New York City.

❧ ❧ ❧

Plans for the new steel steamers contemplate the purchase of 100 electrical propelling sets, suitable for large-size cargo steamers, and of the type satisfactory in naval vessels. This is an innovation for merchant ship construction. The experience of the naval vessels, however, indicate a remarkable economy and dependable action from electrical propelling machinery. The ease of manipulation that is a feature of this mechanism also is an attraction, it being said that running an electrically propelled ship is not much more difficult than running a trolley car.

Electric Propulsion for New Vessels

The problem of obtaining men to act as electrical engineers on the vessels has been solved, it is believed, by the decision to ask for the services of men in charge of big power plants throughout the country. As soon as these men get their "sea legs" they will be qualified to take charge of the electrical apparatus on the new ships.

(C) Press Ill. Svce.

A view of a naval gun crew at work below decks is an oddity, added interest being given in this instance by the head protection. The two men in the center are swabbing the piece preparatory to the insertion of the new projectile, held by the man on the left, as the gunner on the right stands in readiness to close the breech

THE DYNATRON

A Vacuum Tube Possessing Negative Electric Resistance*

By Albert W. Hull, Ph.D.
Research Laboratory, General Electric Company, Schenectady, New York

(*Continued from June* WIRELESS AGE)

The wave-form depends on the ratio of inductance to capacity and resistance. According to theory we should expect a perfect sine wave when $L \div C$ is very nearly equal to Rr (since in this case the circuit fulfills the condition of simple harmonic motion), with increasing distortion as the ratio of $L \div C$ to Rr increases. As this is a question of considerable importance, a series of oscillograms was taken with different ratios of $L \div C$ to $R\,r$. They are shown in figure 12. The circuit is that of figure 11, except that a secondary circuit is coupled inductively with the primary in order to show the form of the wave in a coupled circuit. In each photograph the upper curve gives the current in the coupled circuit, the middle curve the current in the primary circuit, and the lower curve a 40 cycle timing wave. Air inductance and paraffin condensers were used.

Films A to D show the effect of increasing the ratio $L \div C$, keeping R and r constant. As $L \div C$ increases the primary wave changes from a pure sine wave (film A) to a very slightly distorted wave (film B) and finally to a very badly distorted wave (film D). For comparison with curve D, film E was taken under the same conditions and the same frequency, but with a proper ratio of $L \div C$. It is a good sine wave. It is to be noted that the oscillation in the coupled circuit is a fair sine wave, even when the primary is badly distorted.

6. DYNATRON IN INDUCTIVE CIRCUIT WITH IMPRESSED PERIODIC ELECTROMOTIVE FORCE

If a periodic e.m.f, represented by $e_0 \cos \omega t$ be impressed upon the circuit of figure 11, the forced oscillations which it impresses upon the circuit may attain a much greater value than in a circuit containing no dynatron. This can best be seen from mathematical analysis. The equations of the circuit are:

$$I\,R + L\frac{dI}{dt} = E - e_0 \cos \omega t$$

$$i = \frac{E}{r} + i_0$$

$$I + i = -C\frac{dE}{dt}$$

whence

$$\frac{d^2E}{dt^2} + \left(\frac{R}{L} + \frac{1}{C\,r}\right)\frac{dE}{dt} + \frac{1}{LC}\left(1 + \frac{R}{r}\right)E + \frac{i_0}{LC}(R+L) = \frac{e_0}{LC}\cos \omega t$$

*Reprinted by permission from the Proceedings of the Institute of Radio Engineers.

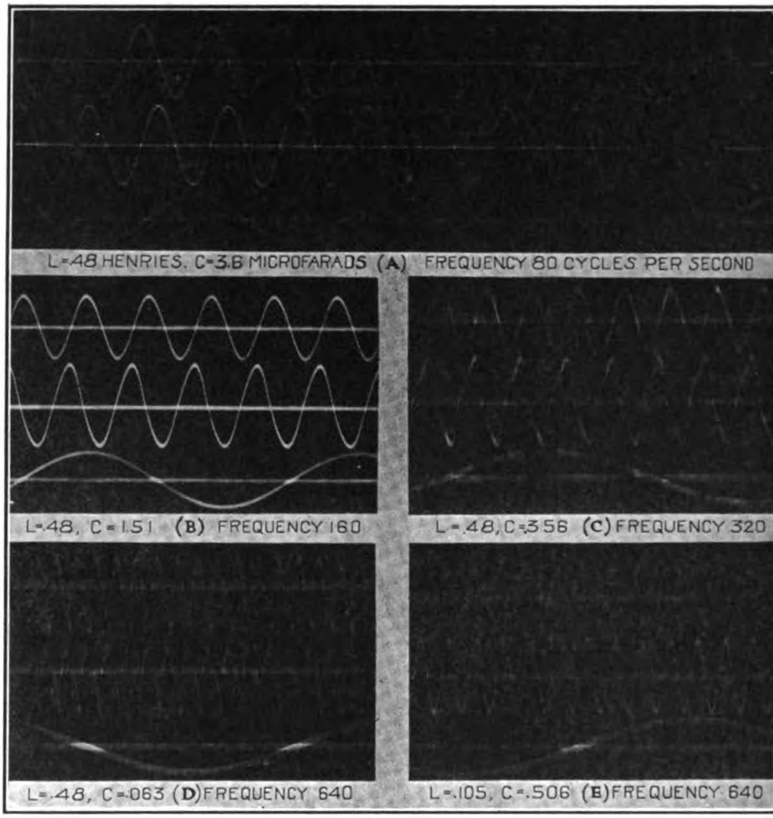


Figure 12—Effect of Capacity on Wave Form in Oscillating Dynatron
The middle curve in each film is the current through the dynatron, the upper curve the current in the coupled circuit, the lower curve a 40-cycle wave for comparison

and

$$E = -\frac{i_o(R+L)}{1+\frac{R}{\bar{r}}} + A\,\varepsilon^{-\frac{1}{2}\left(\frac{R}{L}+\frac{1}{C\bar{r}}\right)t} \cos\left\{\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}-\frac{1}{2C\bar{r}}\right)^2}\,t-a\right\}$$

$$+\frac{e_o \cos(\omega t-\theta)}{\sqrt{\left(1+\frac{R}{\bar{r}}-LC\omega^2\right)^2+\omega^2\left(RC+\frac{L}{\bar{r}}\right)^2}} \qquad (4)$$

if

or

$$\frac{1}{LC} > \left(\frac{R}{2L}-\frac{1}{2C\bar{r}}\right)^2$$

$$E = -\frac{i_o(R+L)}{1+\frac{R}{\bar{r}}} + A\,\varepsilon^{\left[-\left(\frac{R}{2L}+\frac{1}{2C\bar{r}}\right)^2+\sqrt{\left(\frac{R}{2L}-\frac{1}{2C\bar{r}}\right)^2-\frac{1}{LC}}\right]t}$$

$$+B\,\varepsilon^{\left[-\left(\frac{R}{2L}+\frac{1}{2C\bar{r}}\right)^2-\sqrt{\left(\frac{R}{2L}-\frac{1}{2C\bar{r}}\right)^2-\frac{1}{LC}}\right]t}$$

$$+\frac{e_o \cos(\omega t-\theta)}{\sqrt{\left(1+\frac{R}{\bar{r}}-LC\omega^2\right)^2+\omega^2\left(RC+\frac{L}{\bar{r}}\right)^2}} \qquad (5)$$

if
$$\frac{1}{LC} < \left(\frac{R}{2L} - \frac{1}{2C\bar{r}}\right)^2$$
where A. B, a, and θ are constants, with the usual meanings.

In either case, provided $R<r$, the amplitude of the forced oscillations is
$$\frac{e_0}{\sqrt{\left(1+\frac{R}{\bar{r}}-LC\omega^2\right)^2+\omega^2\left(RC+\frac{L}{\bar{r}}\right)^2}}$$
and can be made as large as desired (since $\bar{r}$ is negative) by making

and
$$\left.\begin{aligned} Rr &= \frac{L}{C} \\ \frac{R}{r} &= 1-LC\omega^2 \end{aligned}\right\} \quad (6)$$

The first condition is equivalent to zero damping. The second shows that for maximum sensitiveness the frequency ω must be equal to $\sqrt{\frac{1}{LC}\left(1+\frac{R}{\bar{r}}\right)}$, which is the natural frequency of the system when its damping is zero.

It is to be noted that the sensitiveness of the system is the same whether the damping term $\frac{R}{L}+\frac{1}{C\bar{r}}$ is positive or negative. If it is positive, the natural oscillations of the system soon die out, leaving only the forced oscillation given by (4) and (5). If it is negative, the system will generate oscillations of its own of a frequency $\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\left(\frac{R}{2L}-\frac{1}{2C\bar{r}}\right)^2}$ slightly different from ω, in addition to the oscillations of frequency ω given by (5), and these two will produce heterodyne interference. The application of this to radio receiving is discussed below.

7. THE EFFECT OF A MAGNETIC FIELD

A profound change in characteristics is produced by placing the cylindrical type of dynatron shown in figure 2 in a magnetic field parallel to the axis of the cylinder. The electrons from the filament, which in the absence of the magnetic field move in nearly straight lines to the anode and pass freely through its holes (figure 13 a), are constrained by the field to move in spirals, and strike the anode more or less tangentially (figure 13 b), so that a much larger proportion are

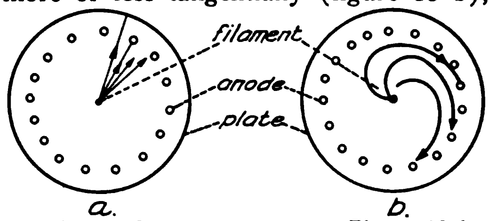


Figure 13 a *Figure* 13 b

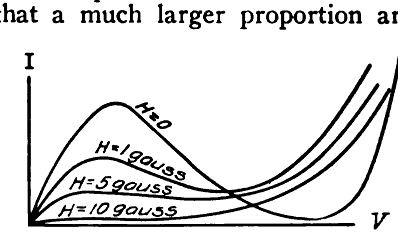


Figure 14

stopped by it. The result is to diminish greatly the number of electrons reaching the plate. Superimposed upon this effect is a restraining effect of the field upon the secondary electrons which try to leave the plate, resulting in a change from negative resistance to positive resistance characteristic.

These effects are shown in figure 14, where each curve represents the voltage-current relation of the dynatron in a definite field. It will be seen that as the field increases the curves become lower and flatter, and soon lose their negative slope altogether. It is thus possible, by varying the magnetic field, to control the behavior of the dynatron. This method of control is especially applicable to the radiophone, as will be explained later.

8. The Pliodynatron

An electrostatic field may be used instead of a magnetic field to control the number of electrons reaching the plate. It has been shown (see figure 6) that the effect of changing the number of electrons leaving the filament, by varying its temperature, is to change the negative resistance without affecting the other characteristics of the current voltage relation. If the temperature of the filament could be easily and rapidly changed, this would be an effective means of controlling the dynatron. The same result may be accomplished, however, by the electrostatic action of a grid close to the filament; that is, by the application of the pliotron principle. A dynatron which thus utilizes the pliotron principle is called

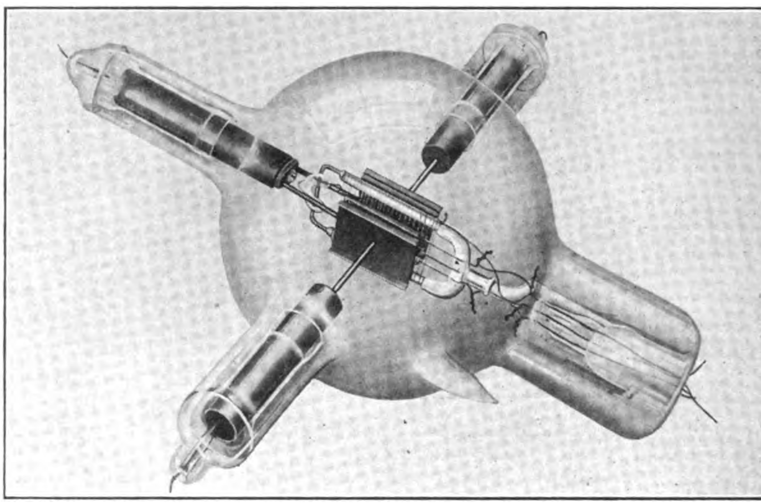


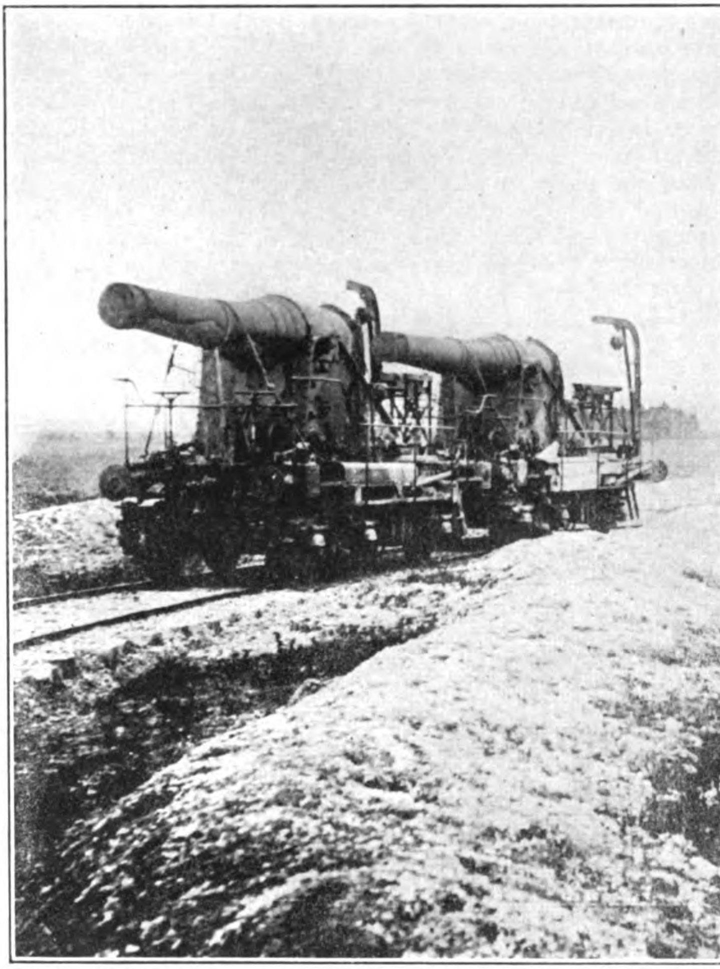
Figure 15—General Electric Company Pliodynatron

a *pliodynatron*. Its construction is the same as that of the simple dynatron with the addition of a "control member," which may be a grid surrounding the filament (figure 2, g) or a metal rod inside the (spiral) filament (figure 2, f).

Its relation to the pliotron can be most clearly seen in the "plate type" of pliodynatron, a photograph of which is shown in figure 15. It is identical in construction with the pliotron except for the addition of the perforated anode.

The characteristics of the pliodynatron can be seen from figure 6, if for filament temperature we substitute grid potentials. The steepness of the curve increases, that is, the negative resistance decreases, with increasing grid potential. The relation is capable of more exact statement: It is known that in the pliotron, with constant anode voltage, the number of electrons leaving the filament is proportional to grid potential over a wide range, and this must be true in the pliodynatron, where the anode voltage is always constant. It may be shown, both theoretically and experimentally, that the negative resistance is inversely proportional, over a wide range, to the total number of electrons leaving the filament. The negative resistance is therefore inversely proportional to grid potential. The behavior of the pliodynatron in circuits containing resistance, inductance and capacity is therefore given by equations (1) to (6) if we replace R in these equations by $R_0 \div v$, where R_0 is a constant and v the potential difference between grid and filament.

The negative resistance of the pliodynatron makes it a powerful amplifier. An increase of grid potential, by increasing the current through the load in the plate circuit and hence the voltage drop over the load, lowers the voltage of the plate. In the pliotron this lowering of the plate voltage tends to decrease the plate current, and thus opposes the effect of the grid. In the pliodynatron, however, a decrease in plate voltage means an increase in current, which may be very large



(C) Press Ill. Svce.

All preconceived notions of the conduct of warfare seem to have gone topsy-turvy in the present conflict. The photograph shows guns of large calibre mounted on specially constructed railway cars for easy mobility, thus competing with the lighter pieces of the field artillery. Guns of the type illustrated were mainly used, before the present war, in fixed positions for coast defense; they are now available for quick transportation to the front to give very material aid in the heavy bombardment which precedes an attack on the trenches. Many thrilling duels have been thus fought with the enemy prior to attack, the monsters on opposing sides endeavoring to put each other out of business by a well directed shot according to the fire data supplied by wireless from observation airplanes

if positive and negative resistance are nearly equal. This will be clear from figure 16, where the curves marked v_1 and v_2 represent the current voltage relation for the grid voltages v_1 and v_2 respectively of a pliodynatron and a pliotron. If we start with an initial current of i_1, corresponding to plate voltage E_1, and raise the grid voltage from v_1 to v_2, the current tends to rise to i_2. On account of the decrease in plate voltage, however, the pliotron current will rise to some smaller value i', while the pliodynatron current will rise to a much larger value i''. The advantage to be gained in this way may be large, if the resistance in the circuit is high. For example, the maximum aperiodic voltage amplification thus far obtained with a pliotron is about 15-fold, while with a pliodynatron we have obtained 1000-fold.

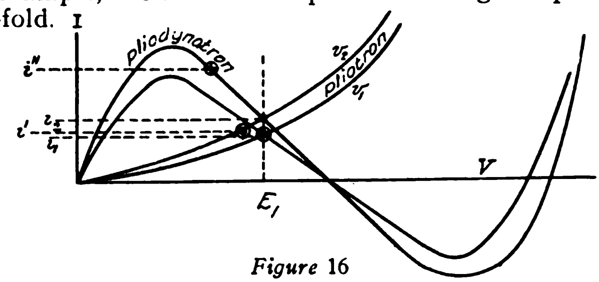


Figure 16

A better method of representing the characteristic behavior of the pliodynatron is, instead of plotting the current to the plate against plate voltage, to plot it against the total voltage across plate and series resistance, as in curve E, figure 8. A series of such plots, for different grid potentials, is shown in figure 17. The voltage plotted is now constant, being that of the battery, and for any given value

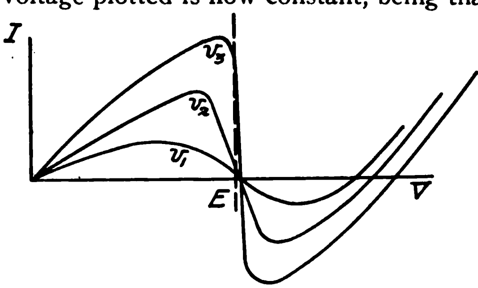


Figure 17

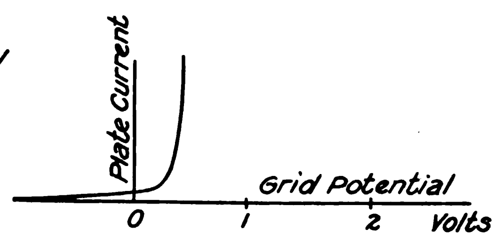


Figure 18

E we obtain the currents corresponding to different grid potentials from the intersections of the curves with a vertical line through E. If E is taken just to the left of the point where the curves cross the axis, the current will increase at first slowly and then very rapidly with grid potential, as shown in figure 18. The amplification is, under these circumstances, both asymmetric and high, and the tube should constitute a good radio receiver. This is discussed more fully in Section 14 below.

Applications of the Dynatron to Radio Work

9. Dynatron as Generator of Radio Waves

It has been shown in section (5) that the dynatron always oscillates providing $Rr < \frac{L}{C}$, where R and r are the positive and negative resistance, respectively, of the circuit, L the inductance and C the capacity. The frequency of oscillation is approximately $\frac{1}{2\pi\sqrt{LC}}$, and may be given any value from 1 to 10,000,000 by changing the inductance and capacity alone. It has also been shown that for low frequencies the oscillations are very nearly pure sine waves provided $L \div C$ is not too great compared with Rr. Theory indicates that this should be true for all frequencies, and a search for harmonics at radio frequencies has verified the expectation.

The dynatron therefore satisfies all the requirements of a radio generator, and has the advantage that its operation is invariable and free from lag, and that the frequency may be given any value by changing a single inductance or capacity. Its oscillations may be controlled either by opening and closing the main circuit, or by changing any one of the four factors L, C, R, and r in accordance with the condition of oscillation given above. Its efficiency is low, probably less than 50 per cent. under best conditions. This is not, however, a serious limitation, except as regards the cost of power, since the tubes are capable of running very hot without deterioration. The maximum output at radio frequency of the tubes thus far constructed is about 100 watts, but no effort has been made to develop a high power tube.

It is generally necessary to transform the radio energy by means of a coupled circuit. In the discussion thus far the effect of such a coupled circuit on the oscillation has been neglected. The calculation for the case of inductively coupled circuits is not easy, but it may be shown experimentally that conditions similar to those derived above hold, even when the coupled circuit absorbs nearly all of the energy.

10. Pliodynatron as Radio Telephone

The simplest method of controlling the oscillations of the dynatron is to vary the negative resistance, by means of a grid around the filament, as in the pliodynatron. It has been shown in Section (8) that the negative resistance of the pliodynatron is inversely proportional to grid potential. Hence if the ratio of inductance to capacity and resistance be initially just large enough to produce oscillation (which is also the condition for producing pure sine waves), a slight decrease in grid potential will stop the oscillations.

If the negative resistance part of the pliodynatron curve, instead of being straight, is curved like that of figure 4, the oscillations will not fall abruptly from full value to zero when the grid potential is reduced beyond the critical value, but will be gradually reduced in amplitude as the grid potential is decreased. This is exactly what is required for the radiophone and it is easy to make pliodynatrons which have this characteristic.

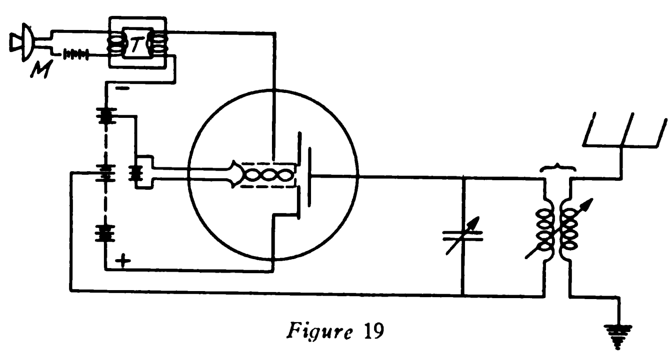


Figure 19

The connections are shown in figure 19. The oscillating circuit is the same as figure 11, except that the dynatron is replaced by a pliodynatron, and is coupled inductively to the antenna. A microphone M, coupled through the transformer T to the grid circuit of the pliodynatron, serves to control the amplitude of the oscillations. A battery of a few volts, between grid and filament, keeps the grid always negative with respect to filament.

It is found that, with a proper ratio of inductance to capacity, the amplitude of the radio waves is very nearly proportional to the grid potential, and hence to the instantaneous displacement in the vocal wave. This was proved for constant grid potential by means of a hot wire ammeter in the antenna circuit, and for alternating grid potentials by impressing a sine wave on the transformer T, and observing the form of the rectified radio waves in a coupled circuit containing a kenotron rectifier and oscillograph.

Under these circumstances, it was found that speech transmitted to the microphone M and received at a station a few miles distant suffered very little more distortion than in the ordinary wire telephone. With a small tube giving about 10 watts, it was possible to radiophone 16 miles (26 km.) with good intensity and articulation. No attempt has been made to telephone greater distances, or to develop high power pliodynatrons. The maximum output of a single tube which it has been possible to control thus far is about 60 watts.

11. Magnetically Controlled Dynatron as Radio Telephone

Instead of controlling the negative resistance by a grid, as in the pliodynatron, we may use a magnetic field, as explained in Section (7). It is seen from figure 14 that the change both in slope and amplitude of the negative resistance portion of the curves is a continuous function of the magnetic field strength. Hence if the magnetic field coil is connected in series with a microphone, the amplitude of the radio oscillations may be controlled by the voice, as in the pliodynatron. The energy needed to set up a magnetic field of the required strength is small, and can easily be furnished by the microphone circuit, but the impedance of the coil tends to choke out the higher voice frequencies.

12. Dynatron as Amplifier and Detector

It has been shown in Section 6 that a small periodic electromotive force impressed upon a circuit containing a dynatron may be amplified in any desired ratio by properly adjusting the capacity and inductance of the circuit; that is, the resonant value of current or voltage in the dynatron circuit is infinite, except as it is limited by the length and straightness of the dynatron curve. The impressed oscillations may be radio oscillations in an antenna coupled with the dynatron circuit, and the amplified voltage or current be used to operate a detector. It is important to notice that the energy consumed in the detector does not decrease the amplification, since the dynatron can be adjusted just to neutralize this loss, in addition to the other losses in the oscillating circuit. The simplest examples

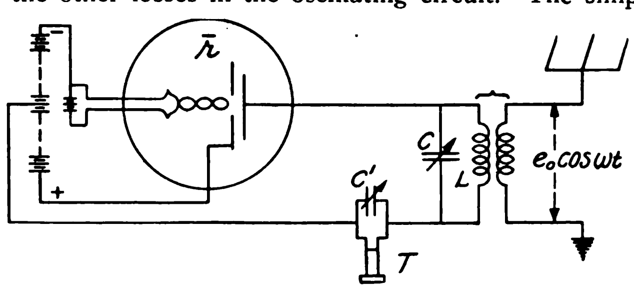


Figure 20

are when the detector losses are of a pure resistance nature, as, for example, when a high resistance galvanometer, such as one of the Einthoven type, is inserted in the oscillating circuit, or an audion with leaky grid, the leakage being proportional to voltage, is connected across any part of the oscillating circuit. In these cases, equation (4) of Section 6 applies directly, the positive resistance R being the total resistance of the circuit, including galvanometer and grid. In the cases where the detector is inductively coupled to the oscillating circuit, the impedance due to the coupling is equivalent to a resistance, so that similar relations hold.

Since the amplitude of the "resonant current" in the dynatron circuit is limited by the length and straightness of the negative resistance curve, it is evident that if we operate the dynatron in a region very near one end of the curve, as at A or C, figure 3, the current will be asymmetric, and the dynatron may itself be used as a detector. Suitable connections are shown in figure 20, where a telephone T with condenser C' across its terminals is inserted directly in the dynatron circuit. The distributed capacity between turns of the telephone offers low resistance to radio frequencies, so that the conditions of amplification discussed above still hold.

But the high inductance of the telephone will, according to condition (3) of Section 5, cause the circuit to oscillate at audio frequency, unless its resistance be very high, or a condenser C', of suitable capacity, be connected across its terminals.

The circuit shown in figure 20 has two advantages, in addition to its high amplification, viz.:

1. The ratio of inductance to capacity may be adjusted so that the circuit oscillates with natural frequency very near that of the radio waves, as explained in Section 6, thus producing heterodyne beats.

2. The capacity C' and negative resistance $\bar{r}$ may be so adjusted as to neutralize the resistance of the telephone for a particular audio frequency, determined by the product of C' and telephone inductance, and if this frequency be made the same as the group frequency of the incoming radio waves, the sensitiveness becomes very great.

These predictions have been verified separately by experiment. In order to test the behavior of the complete circuit, it was set up as in figure 20, and its reception of signals from a small spark set compared with that of a sensitive audion. For very weak signals the audion was the more sensitive, indicating small asymmetry in the dynatron oscillation. For medium signals, however, the dynatron response was many times stronger, and its intensity could be increased to almost any degree by adjustment of the capacity C'.

It is interesting to note that the coupling in a circuit like that of figure 19 may be made very close without affecting the selectivity, since the condition for selectivity, viz.: a small damping factor, still holds. This is true both for the antenna coupling and that of the auxiliary detecting circuit, when one is used. The fact that sensitiveness and selectivity are independent of both resistance and coupling coefficient makes it possible to use a much more effective ratio of transformation than has hitherto been practicable.

13. Use of Dynatron for Neutralizing Resistance in Radio Circuits

The negative resistance of the dynatron may be utilized to supply the energy losses of whatever nature, in any circuit, and the circuit thereupon behaves, as regards selectivity, damping, and sensitiveness to external stimuli, like a circuit

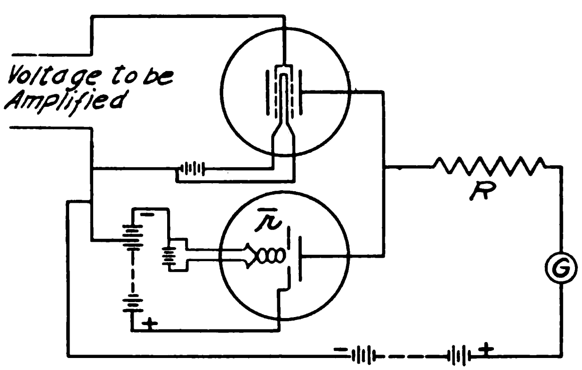


Figure 21

having zero resistance. The amount of energy fed into the circuit by the dynatron is i^2r, where r is the negative resistance and i the current (steady value or r.m.s.) through the dynatron. Examples of this use of the dynatron in simple circuits containing resistance, inductance and capacity have already been given in Sections 3 to 6. Two further examples will illustrate its use in circuits where the resistance characteristic is more complex.

(a) Dynatron in Plate Circuit of Pliotron for Aperiodic Amplification.

The current through the pliotron, for constant grid voltage, increases with increasing voltage of the plate, that is, it has the characteristic of a positive resistance, which limits its amplifying power as explained in Section 8. This resistance characteristic may be neutralized by connecting a dynatron in parallel with the pliotron, as in figure 21. Using a pliotron whose "positive resistance"

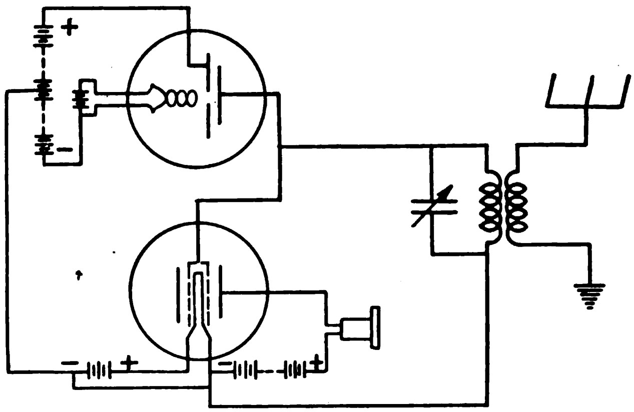


Figure 22

was 100,000 ohms, and a series resistance of 250,000 ohms in the circuit, we were able in this way to increase the d. c. voltage amplification from 12-fold, for the pliotron alone, to 625-fold. A further advantage in this connection is that the dynatron can be operated at such a voltage that its current is just equal and opposite to that of the pliotron, so that the total current through the circuit is zero. This allows the use of a more sensitive measuring instrument.

(b) Dynatron in Grid Circuit of Pliotron Detector.

The increase in voltage of the grid of a pliotron detector is opposed by a leakage current which increases with voltage, as in a positive resistance, and also by the counter e. m. f. and losses in its own and the coupled antenna circuit. These losses may be neutralized by a dynatron in parallel with the grid, as in figure 22. With this arrangement the intensity of weak signals from a spark set was increased from audibility to a roar.

The dynatron, instead of being connected directly to the grid of the pliotron, may be in a separate circuit which is inductively coupled to any part of the grid or antenna circuit.

14. Pliodynatron as Amplifier and Detector

It has been shown in Section 8 that a pliodynatron in series with a suitable resistance is capable of producing an aperiodic voltage amplification of 1000-fold. To maintain this amplification requires constant batteries and continuous attention. A value of 100-fold, is, however, very easy to maintain. By connecting two pliodynatrons in series a total amplification of 10,000-fold has been obtained. With this amplification it should be possible to receive radiograms on an aperiodic antenna.

This arrangement of pliodynatron and positive resistance is equally applicable to a tuned antenna circuit. The connections are shown in figure 23. The telephone itself furnishes sufficient resistance, and a condenser C' connected across the telephone is adjusted so that its capacity is just sufficient to keep the circuit from oscillating, according to condition 3, Section 5. With this connection, the amplification is asymmetric, i. e., different for posi-

tive and negative variation in grid potential, as shown in figure 18. To increase the selectivity, a circuit LC, tuned for radio frequency may be included in series with the telephone, and either adjusted to the verge of oscillation, or allowed to generate oscillations for heterodyne work. The telephone should, in case of radiograms, be tuned for the group frequency of the

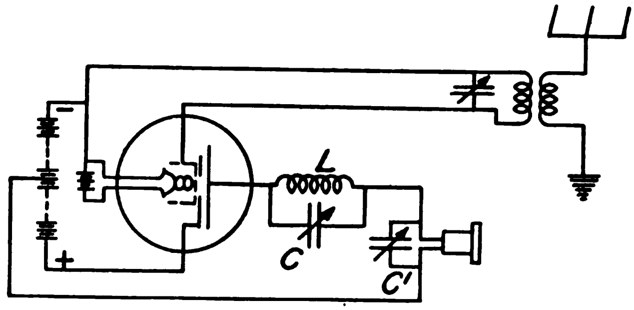


Figure 23

signals. It may then be brought to the verge of audio-oscillation by adjusting the negative resistance, and the final adjustment for radio sensitiveness be made by varying the ratio of L to C, keeping their product constant.

In the circuit of figure 23 all the losses may be compensated, in the manner just described, except those in the grid circuit and antenna. Figure 24 shows a modification of the circuit of figure 23 in which the grid and antenna losses also are compensated. The modification consists in connecting the grid, not to the filament, but to a properly chosen point P on a resistance R in series with the plate. The pliodynatron is then operated at such voltage

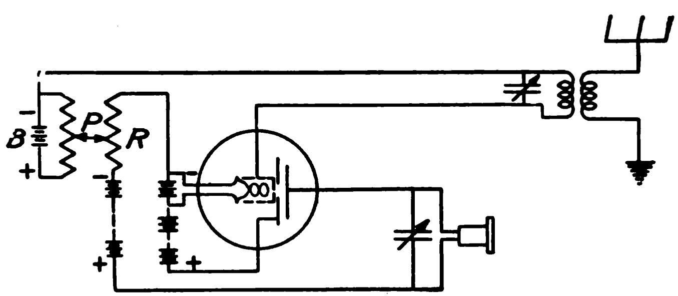


Figure 24

that the current in the plate circuit is negative (between B and C, figure 3), that is, positive electricity, or its equivalent, flows from filament to plate across the vacuum and thence through the battery and resistance R back to filament. Raising the potential of the grid increases the current through R, and raises the potential of P, which tends still further to increase the potential of the grid. By this mechanism, energy is fed back from the plate circuit, which may be adjusted to furnish any amount of energy desired, into the grid circuit, and by properly adjusting P, the amount of energy thus appropriated may be made just sufficient to neutralize the losses in grid and antenna, without causing oscillation. The antenna coupling should be close, and its resistance may be as large as desired. A potentiometer is shown connected across a battery B the voltage of which is equal to the normal drop in R, for keeping the grid potential constant during adjustment.

(C) Press Ill. Svce.

The generally known need of the German army for rubber appears to accent the reverse conditions in England, where rubber is sufficiently plentiful to permit mounting this small gun on automobile wheels

Experimenters' World

FIRST PRIZE, TEN DOLLARS

A Receiving Set for a Wide Range of Wave Lengths

THE receiving set described herewith was designed to give a wide range of wave length with the least possible number of switches, and to afford the greatest convenience in tuning to a given station.

The general appearance of the front of the cabinet is shown in figure 1, a rear view wiring diagram in figure 2, and constructional details appear in figure 4. The connections for the vacuum tubes are shown in figure 5, and for the crystal rectifier in figure 6.

The cabinet is made of mahogany one-half inch thick; the base should be three-quarters of an inch in thickness. The front panels are four inches wide and eighteen inches long, held in place by brackets 6 and 7 of figure 4,—6 for the top panel "B" and 7 for the lower panel "A." The brackets for panel "A" are fastened by three-sixteenths of an inch 6-32 round head screws on the inside of the panels, which hook over a round head wood screw in the side and bottom of the cabinet. Since panel "B" is movable, and has a contact spring for throwing the mineral detector in circuit, all four brackets are constructed so that the panel can be pushed straight in. The wood screws on the inside of the cabinet are then taken up to hold it in place.

In the lower left hand corner of panel "A" is a push-button for the buzzer tester. I may mention, however, that one can secure the same results by throwing the variable condenser in series with the aerial and then placing it on short circuit. The discharge of the condenser produces a characteristic click which enables one to find the best adjustment of the oscillation detector.

The variable condenser of the primary circuit is connected in series with the aerial and when thrown one point beyond full capacity is placed on short circuit. This does away with the use of a single pole switch.

The tuning transformer is built along the lines of the famous "Blitzen" except that I have arranged it so that the primary and secondary switches require but a half turn. The reader must keep in mind that this set was built some time ago, and of course, I have added many improvements. In building another set of this kind, I would design the tuner like a Blitzen except that I would have the switch contacts on the front after the present design, using the larger circle of contacts for groups of "tens" and the smaller for single turns. The Blitzen permits sharper tuning than my design.

In respect to the secondary, the reader will note that it is tapped and connections are brought out to the front of the panel in the same manner as with the primary coil. The terminals of the secondary taps are connected to small screws in the side of the hard rubber ring. Connection is made through a flexible 15 conductor silk covered cable. As the secondary can only make a quarter turn this cable never gets caught or twisted and does not put undue strain on the connections. (Note particularly the diagrams figs. 2, 5, and 6.)

The secondary condenser is connected across the secondary inductance as usual but is not generally used with the valve. It is found very useful, however, when the mineral detector is employed. These two variable condensers were bought disassembled from the Clapp Eastham Company.

The switch for connecting in the loading coils also connects both the primary and secondary simultaneously in rather broad steps. Adjustments between the coils are made by changing the coupling of the tuner, which with a normal aerial will respond to a little over a thousand meters.

The coupling between the primary and secondary at the loading coils is varied by a small handle and brass rod running through the center of the switch handle (figure 1) to the rear of

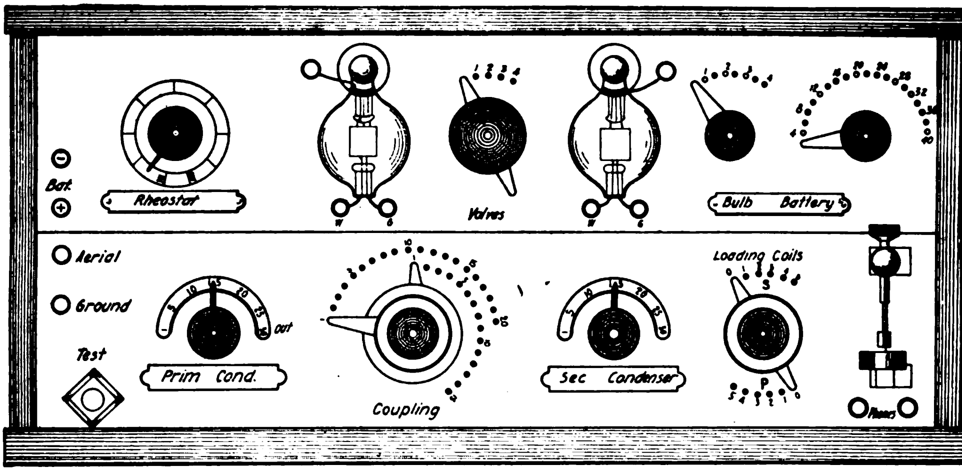


Figure 1—Front view of Cabinet

the set, where a cam made of a piece of one-sixteenth inch brass controls the primary. I am fully aware that a loading coil and a tuner wound dough-nut fashion such as used in this set are condemned as inefficient, but I can truthfully state that by using the mineral detector (not the valve) I have heard South Wellfleet, using the spring of a couch bed for an aerial and the steam radiator for a ground! My station is on the second floor of an ordinary frame dwelling and about sixty miles from the station.

The mineral detector shown to the right of figure 1 is the universal type, first used by the Marconi Company. At the left of the panel, figure 1, will

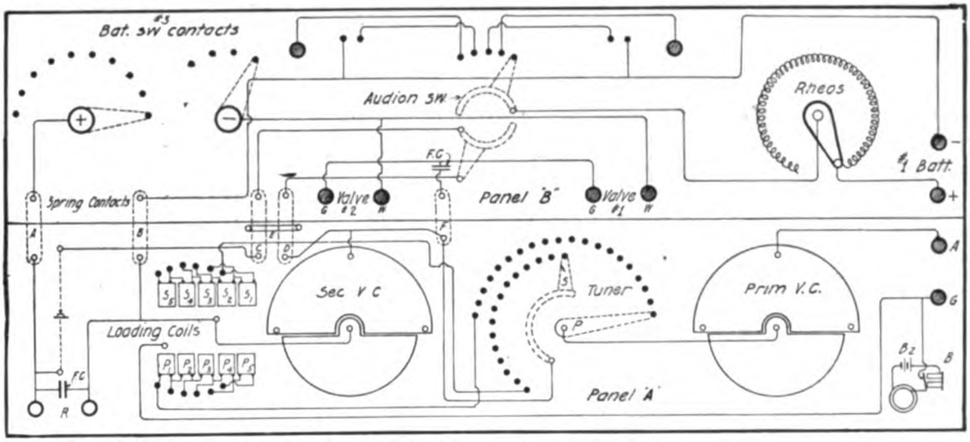


Figure 2—A rear view wiring diagram

be seen the hard rubber binding posts for the aerial and ground connections, and on the right in the lower corner are the posts for the head telephones.

Connections between panels "A" and "B," figure 2, are made with five one-thirty-second inch phosphor bronze springs A, B, C, D, and F. Removing panel "B" allows contact springs C and D to come toward the front of the set making contact with cross piece E and closing the detector circuit.

Since the batteries are mounted on a shelf in the back of the cabinet, in a box, panel "B" can be removed from the set by loosening four screws in brackets number 6 (figure 4) on the inside of the cabinet. It can then be pulled straight out.

The switch for the filaments of the

two vacuum bulbs is built with a second blade or contact which automatically throws the mineral detector out when the valves are thrown in, thereby making unnecessary the use of a double throw switch.

I have always found the ordinary switch for varying the battery current objectionable in that if the points were

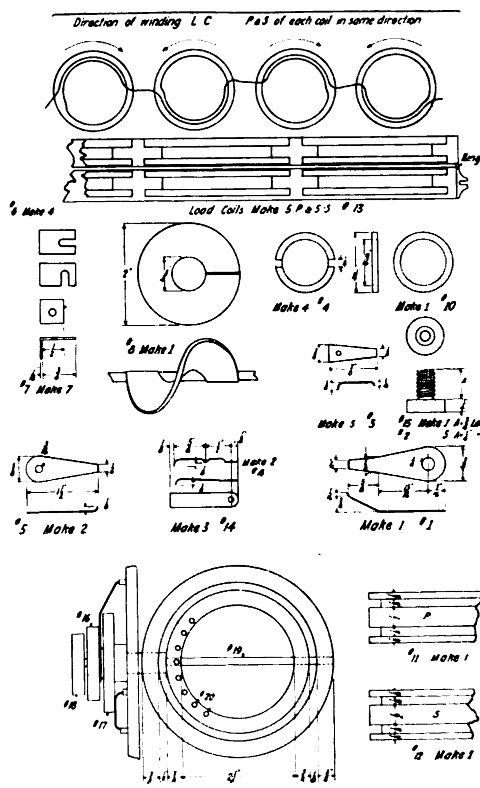


Figure 4—Constructional details

near enough together to keep the blade or contact from sticking between them they would short circuit the set of batteries between these two particular points, and if the points were a greater distance apart than the width of the contact blade, the spring in the contact would force it down and it would hit or catch against the side of the next contact even though both the contact points and the contact spring were "rounded off."

For the above reason I use a dead point between each two live points making the width of the sliding contact a little less than the total distance between the live contacts.

The loading coils are wound on ten

separate hard rubber discs three-and-a-half inches in diameter. They are mounted five to a set, flat on the rear. Five coils are part of the secondary circuit and the other five are for the primaries. They are mounted on a thin piece of fibre sheet, hinged, and mounted face to face with the five secondaries. The first coil is wound clockwise, and the second counter clockwise.

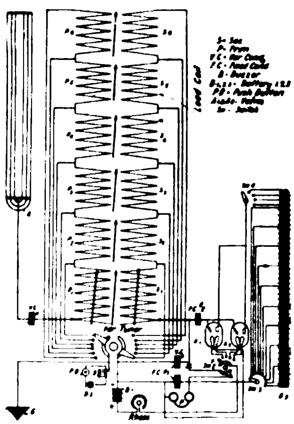


Figure 5—Connections for vacuum tubes

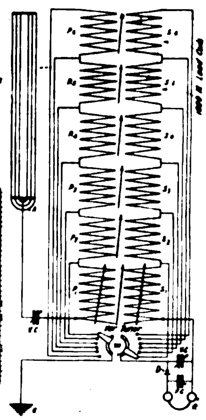


Figure 6—Crystal rectifier circuit

All spring contacts are made of phosphor bronze about one-thirty-second of an inch in thickness.

The contact points are three-sixteenths of an inch in diameter and three-sixteenths of an inch in height. All metal parts are silver plated. The binding posts are made from a six-thirty-second screw one-half inch long, a hexagon nut tapped to fit it, and a small rubber handle with a six-thirty-second tapped bushing made into it.

For the front panels I use one-quarter inch Bakelite and for all handles one-quarter inch hard rubber except the handles on the rheostat, and battery switches which are standard knurled handles about one and one-quarter inch in diameter.

To connect the rod No. 19 (figure 4) to the hard rubber handle it is necessary to put a pin through the handle and rod, also through the rod and secondary coil. The bushing No. 15 is threaded and the primary tapped to fit. The hole through the panel has three-eighths inch clearance, and

therefore the bushing holds the primary coil against the panel. This bushing has a one-quarter inch hole through it which is large enough to carry the tube connected to the primary handle. This tube is scratched on the end to make it rough and it is driven into the primary handle. The contact spring has a one-quarter inch hole and it is soldered on to the tube which extends an eighth of an inch beyond the face of the handle. This keeps the coupling handle far enough away to be easily manipulated.

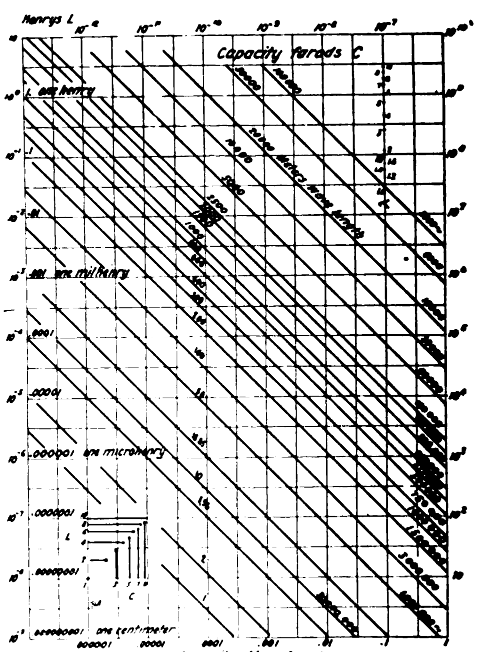
The ring No. 8 is cut from one-sixteenth inch copper or brass and then cut to the center hole and pulled as shown in the drawing. This is soldered on to the one-quarter inch coupling rod.

F. CLIFFORD ESTEY, *Massachusetts.*

SECOND PRIZE, FIVE DOLLARS

Convenient Chart in Making Wireless Calculations

FOR the benefit of your readers I am sending you a chart (figure 2) which I have found convenient in wireless calculations. It shows the relation between concentrated capacity



Concentrated inductance and capacity $\lambda = 1885\sqrt{LC}\ 10^6$
λ = Wave length in meters L = Inductance in Henrys C = capacity in farads

and inductance, and the frequency of a circuit, and also the relation between the c. g. s. units and the practical units. It could be re-drawn on a larger scale with logarithmic subdivisions and reduced photography. Please note that taking the first space of 10 centimeters for inductance as one inch, which it is, the diagram is 16,000 miles in length!

I should like to add finally, that of all of the publications that I have ever read there is none equal to THE WIRELESS AGE.

E. M. TINGLEY, *New Jersey.*

THIRD PRIZE, THREE DOLLARS

An Inductively Coupled Receiving Transformer

A RECEIVING transformer does not necessarily require variable coupling. I have found that for the average work the primary and secondary coils may remain in a fixed relative position provided the construction is carried out as per the accompanying sketch, figure 1. The design shown does not possess any advantage in efficiency over the ordinary coupler, but it is easier to construct.

The principal part of the apparatus is an old-fashioned tuning coil. The windings are removed from one end for about two or three inches and ten or fifteen taps taken from the remainder.

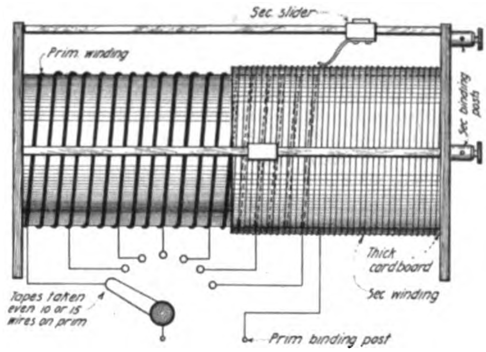


Figure 1—Diagram showing construction of inductively coupled receiving transformer

A piece of card-board is cut just to fit over the bare end of the coil. It should be about two-and-a-half inches in length. A coil is wound over this.

An ordinary piece of stiff card-board can be made pliable and fitted without cracking, by wetting it and then gluing it around the coil when dry. A layer

of wire similar to that wound on the secondary of a receiving transformer, say No. 28 or No. 32, is wound over the card-board. The coil is scraped in two places and sliders attached for variation of the inductance. The two original sliders of the tuning coil can probably be arranged to pass over the bare surfaces. The secondary coil is wound partly over the primary coil and partly over the bare end. It is to be observed, however, that the secondary is outside the primary and not inside as in the usual design.

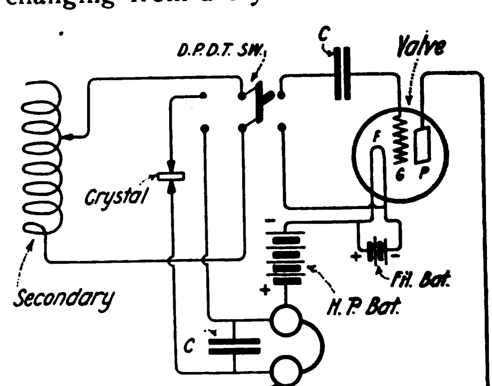
The operation of this tuner is comparatively simple. The number of secondary turns in use can be varied by the position of the sliders, and the degree of coupling in the same way. For example, if in the secondary fifteen turns are required for resonance, these turns can be taken at either end of the coil, and the coupling between it and the primary correspondingly changed. For close coupling both sliders are moved along the secondary coil until they are directly over part of the turns of the primary winding.

No definite dimensions are given for the coil as they would naturally vary with the wave length range required. A tuner of this kind will be found to give very satisfactory results.

D. B. Lovis, *Massachusetts.*

Changing from the Vacuum Tube to the Crystal Detector

I HAVE found a double pole double throw switch of great advantage in changing from a crystal detector to a



Circuit for changing from vacuum tube to crystal detector

vacuum valve. I used a circuit like this quite successfully before the War.

One of the important considerations in my circuit is the use of a condenser across the telephones while employing the valve. This I find to be a benefit and not a detriment. In using either oscillation detector, parts of the other detector circuit remain attached to the circuit in use, but my experience indicates that this does not affect the signals. I trust that the accompanying diagram will be of interest to the readers of the WIRELESS AGE.

S. F. MCCARTNEY, *Pennsylvania.*

A Multi-layered Tuning Coil

THE multi-layered tuning coil herewith described proves very efficient in receiving undamped waves. It can only be used with a vacuum tube. Good receiving ranges have been obtained with two of these coils ten inches apart. They are wound on a form five inches in diameter and twelve inches long, with grooves one-half inch deep, one-quarter inch wide and one-half inch apart, cut in as shown in figure 1. The ends are made of wood six inches by six inches by three-quarters of an inch. On one of the ends is mounted

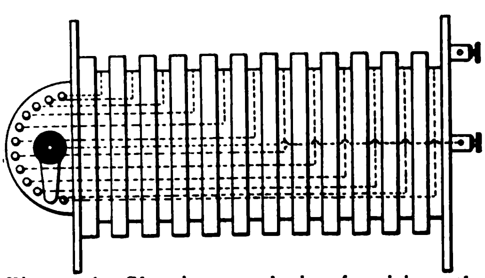


Figure 1—Showing method of wiring the multi-layered tuning coil

a switch base in the form of a semicircle. It has twelve contact points.

Seventy-five turns of No. 32 B. & S. wire are placed in each groove. The terminal of each coil is attached to a switch point and soldered on to it. One wire is brought from the switch lever to a binding post and the beginning of the coil is attached to another binding post. The coil should make a valuable addition to any wireless set after the War.

CHARLES WILDONGER, *New Jersey.*

A Novel Method for Changing Degrees Fahrenheit to Degrees Centigrade or Vice Versa

SOME time or other the average person is confronted with the problem of changing the temperature scale from one system to the other. The writer presents a new method which he believes will be welcomed, for by its use one is enabled to change quite easily and accurately, values from one scale to the other.

To change from C° to F° formula (1) is applicable:

$$(1)\quad F^\circ = \left[(C^\circ + 40^\circ)\,\frac{9}{5} - 40^\circ \right]$$

For changing from F° to C° formula (2) is presented:

$$(2)\quad C^\circ = \left[(F^\circ + 40^\circ)\,\frac{5}{9} - 40^\circ \right]$$

Thus, we should always add 40° and then multiply by a factor which depends upon whether we desire to change F° to C° $\frac{(5)}{9}$ or C° to F° $\frac{(9)}{5}$.

Then we subtract 40°. Whether or not we should multiply by $\frac{5}{9}$ can easily be seen if we always assume that F° are greater than C°. Then, to change C° to F° we use the larger factor, etc.

Two examples follow:

(a) Change 100° C to F°

$$F^\circ = \left[(100 + 40)\,\frac{9}{5} - 40 \right]$$

$$F^\circ = 252^\circ - 40 = 212^\circ\ F$$

This we know to be true. Hence it acts as a check to the method.

(b) Change 32° F to C°

$$C^\circ = \left[(32^\circ + 40)\,\frac{5}{9} - 40 \right]$$

$$C^\circ = 40 - 40 = 0^\circ\ C.$$

This method is logically accurate, for if we examine these simple equations we will find that —40° C = —40° F.

To sum up, the formula amounts to this: add 40, multiply by 5/9 (F° to C°) or 9/5 (C° to F°) and then subtract 40, which gives the required answer in all cases, above or below zero.

E. DUSKIS, *New York*.

A Novel Electric Inspection Lamp and Magnet

THE accompanying illustrations, figures 1 and 2, show an electric inspection lamp and magnet manufac-

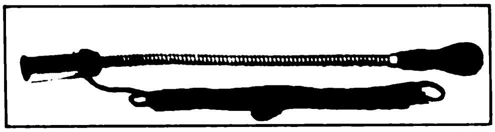


Figure 1—Electric inspection lamp and magnet

tured at Boston, Mass. It is 18″ in length and 1″ in diameter. The magnet is arranged so that the lamp can be used separately when so desired. The lamp is useful for examining cylinders of automobiles, machinery and ammunition inspection. It is equipped with a 6 volt 4 c. p. power

Figure 2—Vest pocket inspection lamp used by physicians and dentists

bulb for lighting, and a magnet for picking up small metal parts which cannot be reached by hand. The photograph, figure 2, shows a unique automatic inspection lamp for physicians and dentists which can be carried in the vest-pocket. It is found to be of great value in medical services for examining the mouth and throat.

Farm Wireless News

THE last vestige of isolation from the world has been banished from the farm. The farmer is no longer dependent upon the telephone, telegraph or newspaper to keep in touch with the outside world. For, if he installs a radio set like that shown in photographs (figures 1 and 2) he will be enabled to receive daily weather forecasts, market quotations and world news.

It may be mentioned that eight years ago, when Archie Banks of Delmar, Iowa, was a sixteen-year-old boy living on the farm of his father, a well-known livestock farmer, he had always been interested in machinery and mechanical devices. In the natural course of events, he installed a wireless outfit. Farmers who live near Mr. Banks now do not have to wait for the belated newspaper which the R. F. D. carrier brings. They are not caught unprepared by any sudden and unpredicted change of temperature, for the weather forecast is known by them as promptly as it is obtained by the man in the city.

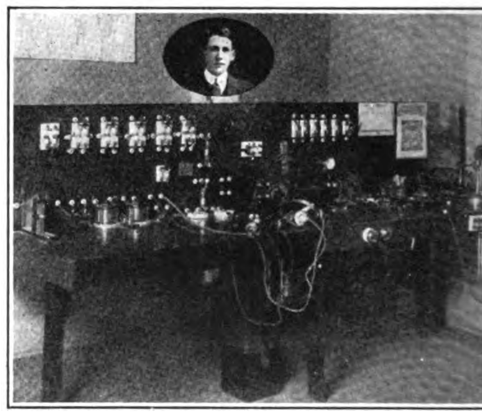


Figure 1—Showing Archie Banks and his wireless room

An interesting side-light surrounding Banks' experiments is the following: The traveler wandering along the road which leads to the Bank's home comes suddenly upon a large sign stretched across the road, upon which is painted in large words this placard: "Eat Honey. For Sale Here. To-day's Weather Report by Wireless

on the Next Curve. Archie Banks." A few rods further on, at the first turn in the road stands the large bulletin board eight feet high by five feet broad. Upon it Banks posts the weather forecasts and the daily news bulletin immediately it is received. Whoever drives by the Banks' home gets the news of the world as promptly and as accurately as the city man gets it from reading the bulletin board of the metropolitan newspaper office. Incidentally, now and then a traveler buys honey. Mr. Banks (now twenty-

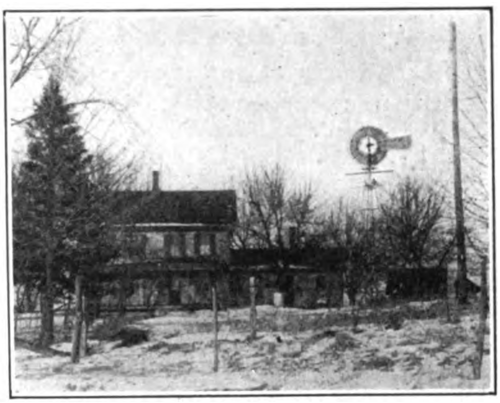


Figure 2—The wireless station on the farm

four years of age) owns and operates a farm of 160 acres, carrying on a general farming business. He has two particular hobbies, however,—electricity and bees. Prior to December 10th, he sold about 3,000 pounds of honey. He could sell much more if he had it, for his honey has a good uniform quality, and Delmar is in the midst of a rich honey section, many car-loads being shipped from there to all points east and west. Banks states that there was no thought of the business possibilities of his wireless service when it was first inaugurated but there is a close connection between the two.

He has received messages from Dariaon, Panama; Hanover, Germany; Mare Island and San Diego, California; Guantanamo Bay, Cuba; Arlington, Virginia; New York City, and all over the world. Signals from stations in the neighborhood of New York are so loud that they can be heard all over the house.

For weather reports and news bulletins he has a receiving set which copies spark stations like Iowa State College at Ames; Springfield, Illinois; and hundreds of other stations.

Signals can be copied from Key West, Florida, twenty feet away. Weather reports are received every day at noon from Ames. Scores of automobiles stop each day to look over the wireless station and to note the bulletins.

FRANK C. PERKINS.

A Telephone Without Diaphragms for Code Practice

TO experimenters and those who are studying the telegraph code in order to aid Uncle Sam, the following code practice device is offered. Buzzers are used more extensively than any other apparatus for this work, the usual method being to connect the telephones across the vibrator and one of the buzzer winding posts. Experimenters who have tried this method have obtained a deafening roar, and therefore the new method I present should appeal to them.

To carry out the idea, first remove the telephone diaphragms and use the receivers without them. A fair note of sufficient strength will be obtained for the usual work. The explanation of this phenomenon lies in the fact that a molecular change takes place in the magnet of the diaphragm due to the fluctuating current.

We have found this effect to be maximum on telephones of about 1500 ohms resistance. If the sound is not loud enough in the ordinary telephone, it is advisable, of course, to leave the telephone diaphragm in and to muffle the sound with a piece of felt or blotting paper.

Another method of reducing the sound is to insert a condenser in series with the telephone. Its capacity should be approximately .0001 microfarad.

E. DUSKIS, *New York*.

EDITORIAL NOTE: The simplest method of reducing the volume of sound emitted by the telephone diaphragm is to shunt it by a variable resistance of 100 or 200 ohms.—TECHNICAL EDITOR.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

A. B. L., New York City, inquires:

Ques.—(1) Can you give me a detailed diagram of the wiring on a four pole Eck motor such as furnished with the Eck Dynamo & Motor Company's motor generators supplied for wireless service?

Ans.—(1) A complete wiring diagram for this armature, which is known as the series

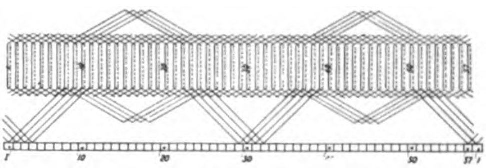


Figure 1—Armature with retrogressive winding

retrogressive winding, is shown in the accompanying figure 1. Please note that the dynamo has four poles and the commutator has fifty-seven bars and fifty-seven slots. The brushes are on the center lines of the poles.

* * *

G. F. B., Jersey City, N. J.:

We can give no advice on your 110 volt A. C. motor because we are not familiar with its construction. A more comprehensive description would be required to give a detailed answer.

* * *

R. W., Portsmouth, Ohio:

Multi-layered receiving transformer coils are tapped in the same way as single layered coils. It is only necessary to bring out a lead from the coil at the desired value of inductance.

The Bureau of Standards Bulletin No. 74 will answer your queries relative to the calculation of inductance and the distributed capacity of a tuning coil.

The effect of the ground lead on a wireless telegraph antenna is in general to double the wave length, the earth acting as an image of the aerial wires.

Replying to your last query, it is possible to exhaust vacuum tubes to .001 micron.

* * *

N. G., Midland, Michigan, inquires:

Ques.—(1) Can a so-called High-Low Auto Lamp be used as a vacuum tube by the addition of an external grid? This lamp, as you know, has two filaments. I

would use one of these as the plate. Is this practical?

Ans.—(1) We cannot answer this question precisely. Good results are obtained from a vacuum tube with an external grid, but whether this particular bulb will give the required electronic emission and the correct operating characteristics to act as an oscillation detector we are unable to state.

Ques.—(2) Can a Fleming valve be constructed to act as an oscillation detector by the addition of an external plate?

Ans.—(2) Yes.

* * *

E. E. M., New Orleans, La.:

It is not possible to answer your query in regard to the amount that the wave length of the antenna will be boosted by the insertion of a localized inductance, unless the inductance or capacity of the aerial is known.

* * *

R. D., Armstrong, B. C., Canada:

Current is not radiated from a wireless telegraph aerial, but the oscillation of the current in the antenna circuit is accompanied by static and magnetic fields which are detached from the aerial and radiated outward at a speed of 186,000 miles per second. The circuit of the antenna is completed through its electrostatic capacity to earth.

* * *

F. B. A., Reading, Pa., inquires:

Ques.—(1) Why is it necessary to use a condenser of a certain capacity for a wave length of 200 meters and to adjust it to the power output of the transformer?

Ans.—(1) This question is answered by the two following simple formulae:

$$W = C\ V^2 N$$

where W = the power in watts to be assumed by the transformer condenser circuit;
C = the capacity of the condenser in microfarads;
V = the applied potential in kilo volts and
N = the frequency of the condenser charging current.

It is readily seen that for a transformer of a given output a condenser of different capacity must be employed for the maximum efficiency.

The dimensions of a condenser for a 200 meter set are determined definitely by the oscillation frequency. Using the simple formula

$$\lambda = 59.6 \times \sqrt{L\ C}$$

we may assign some definite value to L. The minimum value will be about 1200 centimeters. Then from the foregoing formula we can determine the magnitude of C to obtain the required frequency of oscillation or wave length. In other words, if a condenser of excessive capacity were employed, the natural frequency of a circuit, with a fraction of a turn of the primary inductance of the oscillation transformer in the circuit, might be too low for

the required wave length. In other words, the wave length would exceed 200 meters.

Ques.—(2) Is a capacity of .008 microfarad correct for a ½ kw. 13,200 volt transformer?

Ans.—(2) If the set is to be operated at the wave length of 200 meters this is about the maximum capacity that may be employed.

Ques.—(3) How is the speed of a motor in revolutions per minute determined?

Ans.—(3) Preferably by means of a small speed indicator which can be purchased from any machinist's supply house at the price of $1.50.

Ques.—(4) With the above transformer and a condenser of correct capacity what should be the spark frequency of the rotary gap?

Ans.—(4) On the assumption that a non-synchronous rotary gap is to be employed it should be designed to give no more than 300 or 350 sparks per second.

Ques.—(5) How can the above set be adjusted so as to radiate a pure wave?

Ans.—(5) The purity of the wave is ultimately found by means of a wavemeter or decremeter, but in the event that you possess neither you could make this determination in a general way by simply "tuning" in the transmitter on your receiving apparatus. If the signals from your transmitter are heard at only one position of capacity of the shunt variable condenser, it indicates that the set is radiating a single wave, but if the signals can be heard distinctly at two points, a double wave emission is obtained and should be corrected. The correct way to insure a pure wave is to reduce the coupling between the primary and secondary windings of the oscillation transformer until a wavemeter on your receiving set indicates a single wave emission. You must keep in mind that such experiments as you describe will not be permitted during the time of the War.

* * *

H. W. M., Sydney, Nova Scotia, Can.:

The information you have given us is not sufficient to make an accurate calculation of the wave length range of your receiving apparatus, but if it is employed with a carborundum crystal rectifier, the probabilities are that you can put additional capacity across the secondary coil. Better response is obtained with crystal rectifier and vacuum valve detectors by keeping the shunt secondary condenser at low capacity and using large values of inductance for a given frequency of oscillation. We may say in general that the shunt capacity should not exceed .001 or .002 microfarad. A very common value is .0005 microfarad.

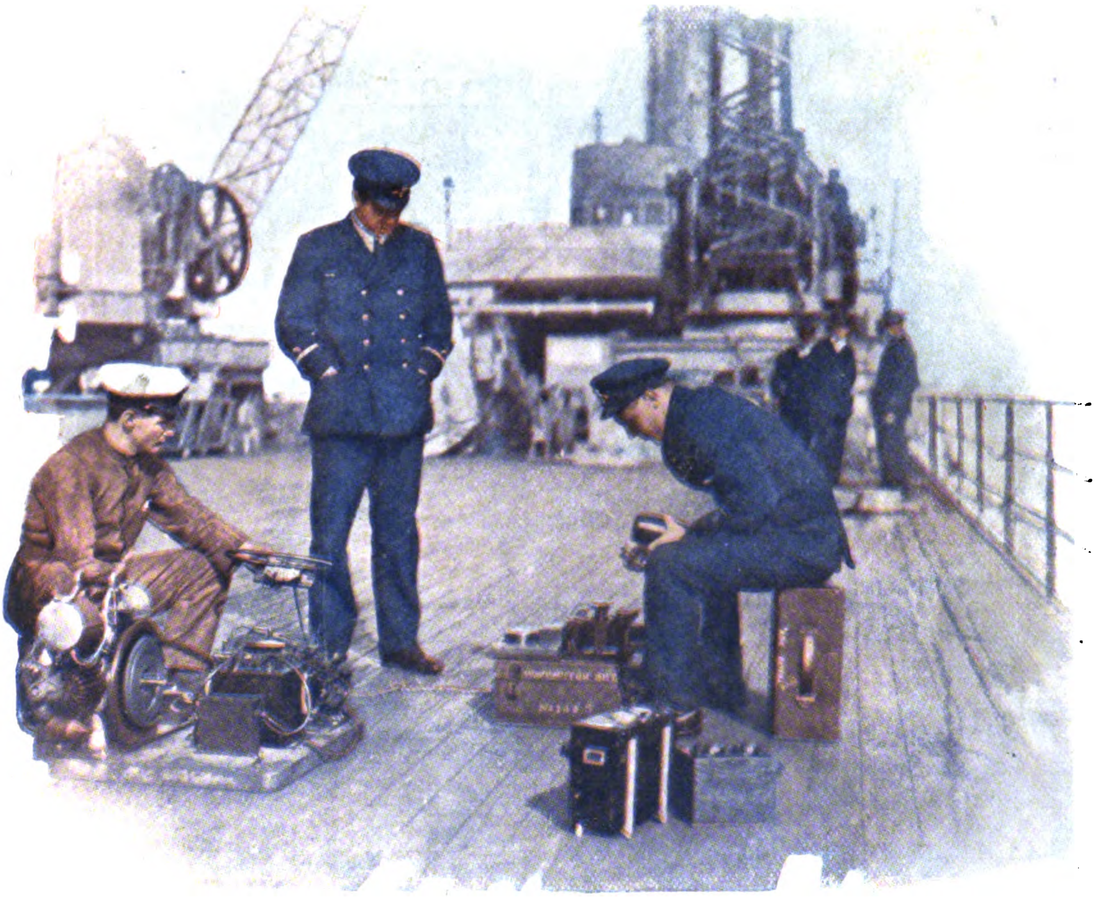
Transil oil, we believe, will work as satisfactorily in the variable condenser as castor oil.

We can give you no information regarding the strange calls you hear. These are probably Government signals.

September, 1918
Price 20c.

C.Y. Table

The WIRELESS AGE



Practical Training Courses in Aviation — Wartime Wireless Military Signaling

And a Special Feature

Pointers on Teaching Code

By GORDON LATHROP of the Marconi Institute

An interesting freak seen on the Alsatian front is revealed in this photograph of a tree hit by a German shell, leaving the trunk split in such a way that the stump has the appearance of a tropical palm

THE WIRELESS AGE

WORLD WIDE WIRELESS

Marconi Medal Lost at Sea

THE Franklin Medal, the highest token of recognition the Franklin Institute of Philadelphia bestows, that was awarded to Guglielmo Marconi, Italy's great inventive genius, on May 15, has been lost at sea, according to a report from the Quaker City.

The medal was despatched by Ambassador Cellere on a transatlantic liner. The ship was attacked by a German submarine in midocean and sunk, the medal, together with the certificate, going down with it.

The medal, a handsome gold affair, will be duplicated and the duplicate forwarded to Marconi as soon as expediency permits.

Wireless to Solve Air Mail Pilots' Problems

THE air mail pilot is solving the problem of flying in all sorts of weather. Prior to the establishment of the Air Mail Service it was regarded as impracticable to make flights with airplanes during severe storms.

On August 1st Lieut. Stephen Bonsal from Philadelphia to Washington ran into a violent thunderstorm at Laurel, Md., at an altitude of 5,000 feet and proceeded on his way to the landing field in Washington without interruption. It was impossible to distinguish any landmarks in such torrents of rain. When he descended to a lower altitude for observation he was near the wireless towers at Radio, Va. To observers he appeared to drop out of the clouds from nowhere at an angle of 45° to a height of about 300 feet when he leveled the plane and made a perfect landing at Potomac Park in the midst of a torrent of rain. The plane arrived on schedule time, not being delayed by the storm. The propeller was slightly damaged by the pelting rain.

Lieut. Bonsal was not assisted by radio guide but depended entirely upon his compass and his judgment from familiarity with the route. When radio and other systems for determining location, which are being tried out, are installed it will greatly simplify flights of this sort where the landscape is obscured and the velocity of the wind render uncertain the traveling of planes.

English Marconi Company Earns Nearly Two Million

A DISPATCH from London says that the profits of Marconi's Wireless Telegraph Co. in 1917 were £383,000 ($1,915,000). The directors have recommended a final dividend of 15% on the ordinary stock and 10% on the preference shares and carried £100,000 ($500,000) to the general reserve fund. The surplus at the end of the year was £376,000 ($1,880,000). The annual meeting was held in London on July 24.

Advanced Aviation School for Wireless Men

THE latest school to be established is the "Advanced School for Radio Operators" at Ellington Field, Tex.

The purpose of this school is to train men who have taken radio school work elsewhere, for actual duty overseas. The course is divided into three sections of one week each and is almost altogether field work. Both French and British systems of working with the artillery will be taught, and the idea is to make conditions as near like battle front conditions as possible. The first two weeks' work will be conducted in dug-outs, just outside of the post, while the third week's work will be in the open, each man being on his own initiative, the work being done with planes. A number of planes will be assigned especially to this work.

Captain Cook, a British officer assigned to duty in this country, has been here, assisting in getting the work started. Lieut. H. B. Lindsay is in charge of the school, Lieut. Fairman is in charge of the instruction, and Lieut. Worrel is in charge of the supplies and maintenance.

S. O. S.—Save or Serve

IN wireless telegraphy "S. O. S." is the code signal sent out by a ship in distress to summon assistance.

Our ship of state is toiling on a voyage to bear democracy to the peoples on earth and bring back to its own people safety against the violence of brutal autocracy and against cruelty and treachery of the Germany of the Hohenzollerns. Buffeted by the winds and waves of circumstance, it is signaling to its loyal citizens for assistance.

"W. S. S." is the Nation's "S. O. S." The country calls for aid. You can answer that call by buying war savings stamps, which will earn interest for you and aid Uncle Sam.

A Dane Invents Steel Soldier Animated by Radio

AN "automatic soldier" is one of the latest developments in war weapons. A Danish engineer has recently taken out a patent for an apparatus to which he has given this name. It is a steel cylinder normally within a larger cylinder, the whole being sunk into the ground vertically. By means of a mechanism operated by wireless the inner cylinder rises to a height of eighteen inches and an automatic rifle mounted on the inner cylinder fires 400 shots in any given direction.

These "automatic soldiers" can be controlled from a central position four or five miles behind the line of defense, says the inventor. They may be seen by the enemy only when they rise.

From trials alrady made it has been shown, it is reported, that a few hundred of these steel soldiers can easily defend a position against infantry attacks, however numerous the opposing force may be. In order to overcome the "automatics" they must be destroyed one by one.

Allies Get Hun Map of British Waters

A MAP of the waters around the British Isles, divided into squares and each square numbered, in order to indicate by wireless to German U-boats the location of allied or neutral ships to be attacked, has been discovered by the allies, together with a code by which wireless stations indicated to U-boats

the nationality and type of ships in any given square. The code was so designed that every message seemed to refer to some innocent commercial transaction. Thus a wireless reading, "First quality packing case, Series 4, No. 432," translated meant "British armored cruiser, four smokestacks, in square No. 432."

German Wireless News Scheme a Failure

ALFRED L. BECKER, Deputy State Attorney General, who is investigating the purchase of the N. Y. Evening Mail by Dr. Edward A. Rumely, has made public the fact that shortly after Dr. Rumely bought the Mail negotiations were opened with Dr. Heinrich F. Albert to establish a wireless news service with Germany.

According to the Deputy Attorney General, the scheme was for a limited number of words to be sent through Sayville, or Tuckerton, and Mr. Becker stated that Dr. Albert agreed to furnish 1,000 words daily at a fixed rate for publication in the Mail. But, according to the Deputy Attorney General, the scheme fell through because Dr. Rumely wanted his own representative in Berlin to gather the news and transmit it, while Dr. Albert wanted to do this. Dr. Rumely is said to have expressed the fear that Dr. Albert would "doctor the news."

U. S. Ships Hear Hun Wireless to U-Boats

WIRELESS operators on American and other ships crossing the Atlantic at night frequently "pick up" orders being sent by the German Admiralty to submarines at sea. The messages are in code, of course, and the submarines never acknowledge receipt of the orders, because if they did some warship of the enemy might get a clew as to the location of one or more of the underseas boats.

These messages to the submarines are from Nauen, a small town near Spandau, where Germany has its great wireless station. Electrical waves produced there will reach some 6,000 miles.

Nine towers are in use, the highest being 850 feet. Last year Nauen sent to the outside world almost 5,000,000 words for the German government.

Naval Rookies Climb Skyward to Paint

THE yearly task, just begun, of painting the two giant wireless towers at the Great Lakes Naval Training Station is a difficult one. Five hundred gallons of paint are required, and men engaged in covering the framework are under intense nervous strain, as they have little space on which to stand and are forced to combat a strong wind at dizzy heights. The Great Lakes Bulletin says that "tests have been made to find how long it would take a man to climb to the top of the tower with a ladder and come back down without the ladder. The record is seventeen minutes."

Ernest T. Edwards Dies Suddenly

ERNEST T. EDWARDS, superintendent of the Eastern Division of the Marconi Wireless Company of N. Y., died August 4th at his home in Maple Avenue, Sea Gate. He was born in England thirty-five years ago, and came to this country ten years ago. He had been employed in England as a wireless operator on coast stations and later on the Cunard line between Great Britain and the United States. He entered the American service and for a while was wireless operator on the American Liner New York. He is survived by his widow and two daughters, Betty and Louise. Funeral services held at his late home on August 6th were largely attended by his former associates in the wireless field.

Some Pointers on Teaching Acquired by a Radio Code Instructor

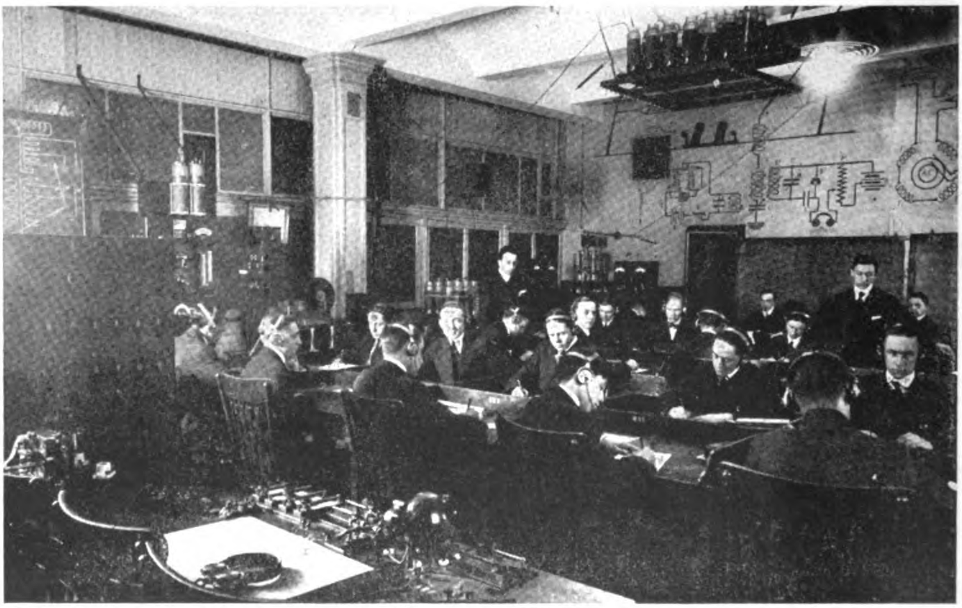
By Gordon Lathrop
of the Marconi Institute

THE writer learned to telegraph while working as a messenger boy in a railroad office. As with most novices in an exacting mechanical art, he was mightily impressed by the glittering generalities indulged in by the "old timers" of the craft. One of these was to the effect that the expert telegrapher was never a graduate of a telegraph school.

"What school turned *you* out?" was, and is yet, frequently snapped over the wire by an irate "old timer" when forced to work with a less skillful mate.

After having worked for a half dozen railroads, both of the commercial land telegraph companies and four press associations, the writer earned the right to consider himself an old timer, telegraphically, and he was wont to hold forth in a like strain. But, fortunately for the art, like so many sweeping statements which pet the vanity of those who so easily voice them, this uncomplimentary dictum about telegraph schools is untrue—untrue in the cold testimony of facts and figures, and fundamentally unsound.

The "old timers" generality however has a degree of justification. Men who, without assistance, have developed sufficient ability in sending and receiving to qualify for their first job, have demonstrated by that very accomplishment their natural aptitude for the art. Further, they have demonstrated persistence and ambition, which, coupled with telegraphic aptitude, produce the skilled worker in the code.



A class receiving advanced code instruction at the Marconi Institute, New York City

The foregoing refers primarily to land line telegraphy and American Morse telegraphers. But the admission of his error concerning telegraph schools in general may serve as a starting point for the writer in telling what he has learned while serving as code instructor to beginners in the New York code room of the Marconi Institute.

There are many and diverse complexities of mental makeup in the Marconi student personnel, but an invariable point to be impressed upon the beginner is that there is but one process of receiving telegraphically, and that deals primarily with "reading by sound."

The writer has learned, however, that the first instruction to be given the beginner is: "Memorize the code in dots and dashes." If he is forbidden the use of code charts, the very first act of the student is to dig up a code chart somewhere to determine for himself what the code actually comprises. In view of the foregoing, the writer submits a code chart for the beginner which outlines a convenient method of memorizing and maintains a progressive relationship between the letters of the alphabet according to the number of dots and dashes employed.

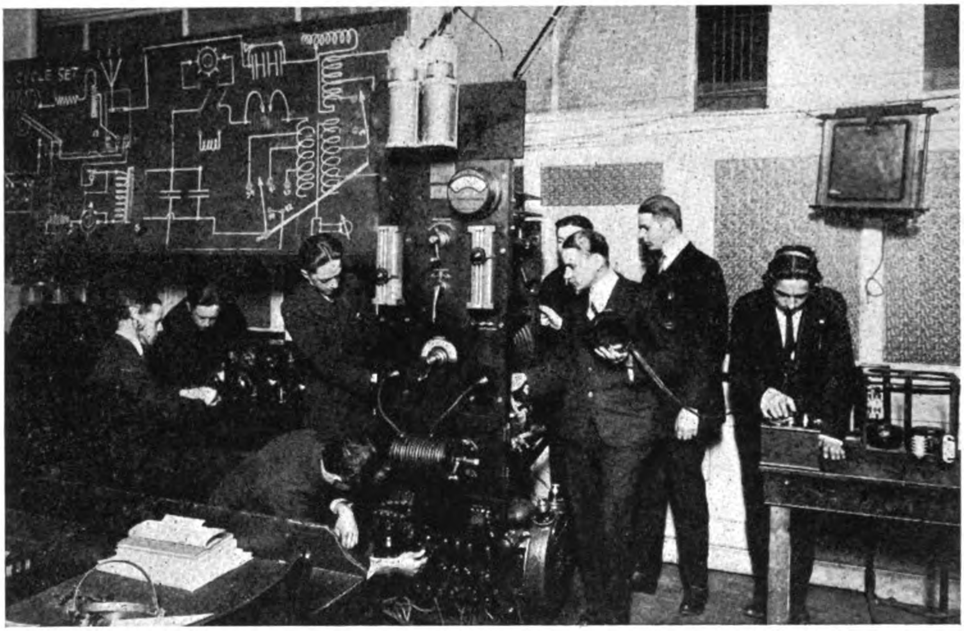
E .	T —	A .—	A .—
I ..	M ——	U ..—	W .——
S ...	O ———	V ...—	J .———
H	Ch ————		
N —.		N —.	N —.
D —..		K —.—	G ——.
B —...		C —.—.	Q ——.—
		X —..—	
		Y —.——	Z ——..
R .—.		U ..—	
L .—..		F ..—.	
P .——.			

This chart has been prepared for the beginner whose mental processes are, say, 60% perceptive and 40% reflective, with a highly developed sense of rhythm. This type of student would instinctively subordinate all tendencies to analyze the sounds into dots and dashes, and would naturally begin to "read by sound." Experience teaches that one who has a natural ear for music will pick up the code work quickly.

In the Marconi Institute we frequently enroll students with the opposite mental makeup; that is, their minds are 40% perceptive and 60% reflective, or analytical. Desire to engage in war service has brought many 40-60 men to the Marconi code rooms. The demand of the period for combination men is unprecedented. Army and Navy aviators must be able to send and receive in the code at a fair rate of speed, in addition to the half dozen other skilled arts in which they must qualify. The Signal Corps of the army and the radio divisions of the navy and marines must have their quotas of combination men—men equally capable in the code and technical operation.

But to return to the writer's purpose of telling what he has learned in the Marconi Institute while instructing others.

Immediately after the beginner has accomplished his first task of memorizing the code in dots and dashes, he is harnessed to the instructor by head telephones and the sending instruction is begun. The student is shown how to hold his hand on the key. The correct "grip" is explained and demonstrated by telling the student to arrange his thumb, index finger and second finger on the key knob in the same manner as he would grasp a pen or pencil to write with a free arm movement. If a pen or pencil were as large as the key knob the relative positions of thumb, index finger and second finger would be



Students receiving laboratory instruction at the Marconi Institute, New York City

practically identical;—thumb against side of key knob as a steadying factor, index finger, convexed preferably, but straight rather than concaved. In this way one makes the correct downward pressure on the knob. The second finger should slip easily in position over the key knob. Just as a hand writing instructor emphasizes the necessity of keeping the hand and wrist relaxed as much as possible, so should the code instructor caution the student about sending. A relaxed wrist precludes "nerve sending," a common error of beginners.

The writer informs beginners there is one general and three specific rules about sending. The general rule is the Golden Rule paraphrased telegraphically: *Send to others as you would have them send to you.* The three specific rules are these:

Make your dot so short and sharp, though firm, that the receiver cannot mistake it for a dash.

Hold your dash long enough—(three times as long as a dot)—so that receiver cannot mistake it for a dot.

Then, having observed rules 1 and 2, knit together the succession of dot or dash, or combination of dot and dash so closely that receiver cannot mistake it for an unintended combination.

The instructor has insufficient time to send each letter to each student a sufficient number of times to enable the beginner's mind to register the proper conception of each sound; so use is made of Marconi-Victor Record Number 1 of the series prepared by Harry Chadwick of the Marconi Institute. On this record a voice calls out each letter in alphabetical order, then the letter is reproduced three times in Mr. Chadwick's perfect style. The beginner, equipped with a head telephone, and sitting before a key, can listen to the first reproduction of each letter in Mr. Chadwick's style, then he can imitate the second and third reproduction on his telegraph key.

To relieve monotony and register the rhythm of each letter in the beginner's mind another method is often used. It is the "follow copy" system advocated by Walter Phillips, originator of the "Phillip's Code," used by all

press telegraphers. The instructor distributes cards on which are pasted sheets containing sentences, five letter unpronounceable combinations of letters, such as "GBXTQ," and ten letter code words, such as "GILLIPA XTE." On the margin of each sheet, before the lines, are numbers arranged consecutively in a column.

The instructor distributes the cards to those who have not advanced sufficiently to copy at the rate of five words a minute or more without the copy as reference. Then he sends from the card, line by line, to those who can "read by sound," calling off the number preceding that line before beginning so those who hold copy may follow the sending.

When the opportunity occurs, the writer talks to each beginner. He tries especially to appeal to the 40-60 boy or man—the type whose tendency is to analyze—to break the sounds up in dots and dashes, who by painful reasoning processes tries to detect the letters as they are sent. This, in effect, is the burden of the writer's talk to the beginner:

"You have learned that A, for instance, is composed of a dot and a dash. But so is E, T. The letter C is dot-dash-dot-dash, it is true, but those same components make up the combinations T R, N N, or K E. The letter A in wireless telegraphy is a rhythm; a staccato note and a legato note occurring in quick succession. This principle applies throughout.

"Your job is to tuck away in your mind a correct concept of the sound* of each letter, numeral and punctuation mark, and by practice learn to associate that sound immediately, and without conscious effort, with the letter which it symbolizes."

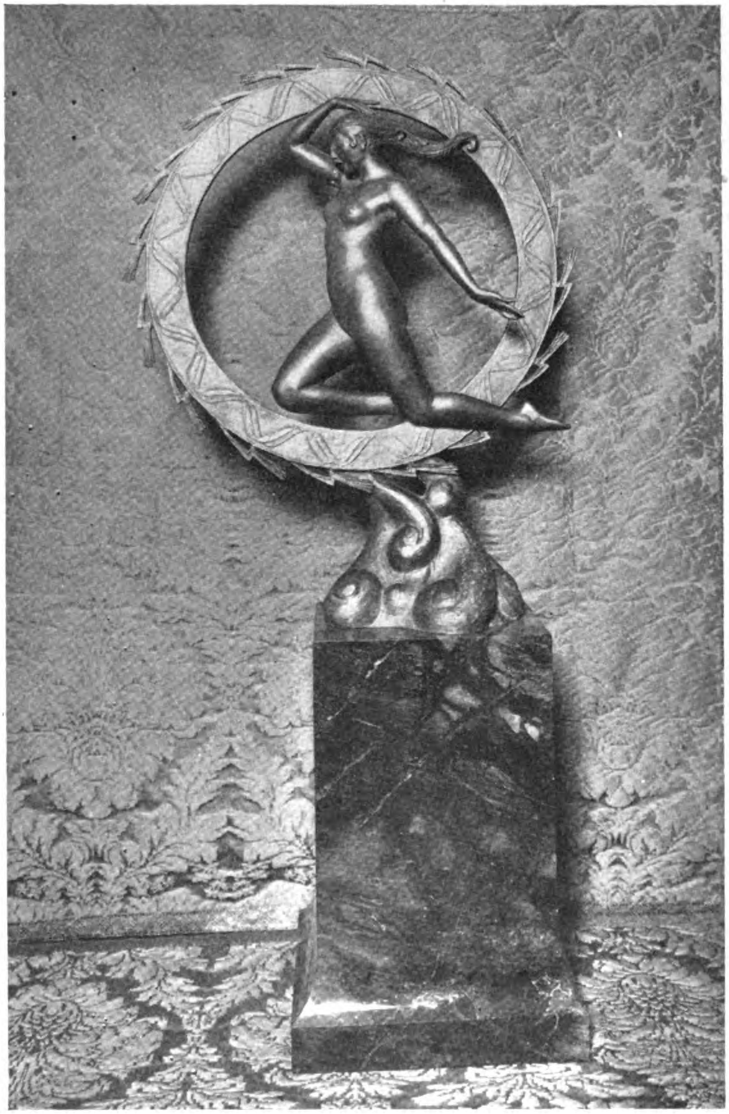
These, then, in summary, are the instructions which in the writer's opinion, tend to lay the right foundation for the telegraphic aspirant: Memorize the code to learn the arrangement of the elements with which you work; learn the proper grip for sending and model your style after that of an expert telegrapher—one who observes rules one, two and three and the general rule—subordinate from the start the tendency to analyze the sounds by "follow copy" practice, if you can obtain it—by all means at your disposal get yourself as quickly as possible into accord with the first principle of receiving—reading by sound.

In conclusion, let it be said that for the 40-60 student there is no royal road to success in mastering the art of telegraphy. Systems of instruction nor methods such as the phonetic syllable idea will not of themselves bring every student into right accord with the process of reading by sound. The 40-60 boy or man must practice, practice, practice—always on the right basis. After his foundation is properly laid he will progress from table to table and from low speed to high speed with less and less effort. It has occurred, in the writer's observation, that a 40-60 boy or man makes a better code man ultimately than another whose quick perspective faculties gave him such an initial advantage. That is the case if the 40-60 student works hard and persistently to become a 50-50 man while the 60-40 student is content to rely on his instinctive mental processes.

May it not be said to apply in every worthy human activity, as well as in the expert work of the telegraphic craftsman, that it is the frictionless interworking of the instinctive and the cultivated mental machinery which makes for real, satisfying achievement, and produces the evenly balanced, 50-50 man?

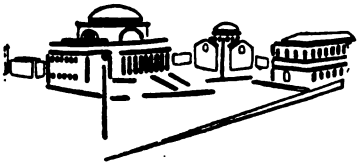
If that be true, and the writer firmly believes it to be true, that is the most important lesson learned by him while serving as an instructor to others.

*By pronouncing the syllable "tuh" for the initial dot, the syllable "duh" for other dots and the syllable "dah" for the dash, an oral representation of any letter's rhythm may be produced. So far as the writer has been able to learn, the use of these syllables—for instance, the letter "F" would be pronounced "tuh duh dah duh"—is the most practicable application of the phonetic method of learning the code. The writer would be glad to give credit to the originator of this idea if he could determine to whom the credit is due.



Above is shown a sculptor's conception of "Radio," a subject which the weilders of the scalpel have hitherto evaded with a wholesome respect for the difficulties it presents. Just that much credit is therefore due Edward Field Sanford, Jr., for his expression in bronze of the wildly onward-rushing electric waves. The figure of "Radio," rushing through space with an unearthly wind blowing her hair backward, and with every line eloquent of arrow-like speed, dominates the whole. Surrounding her is a circular halo, or ring, symbol of infinity and suggesting all the circular forms so common in radio apparatus. The coil, the winding, the rotary gap, and the dynamo all contain the circle, and all of these are closely associated with radio methods. The statue was executed for Dr. Alfred N. Goldsmith, for many years a close friend of the sculptor.

Progress in Radio Science



A Rectifying Spark Gap for High Tension Alternating Current

WHEN the condenser charge breaks down in a circuit carrying a powerful current and containing a spark gap of which one electrode is a flat surface and the other electrode a rod with a tapered or rounded end, the discharge across the gap is a plain alternating current arc resembling in appearance a candle flame. This is essentially what takes place when the secondary circuit containing the spark gap is in resonance with the primary power circuit which charges it through an inductive coupling. If the primary circuit and the secondary circuit are not in resonance, the discharge across the gap takes the form of irregular stringy white sparks. In the former case, the gap becomes conductive and current oscillates across it in the same frequency as that of the primary circuit; such oscillations are too low in frequency to be utilized for radiating Hertzian waves. In the latter case, oscillations of current occur in the circuit and internal losses are sustained, diminishing the efficiency of the circuit.

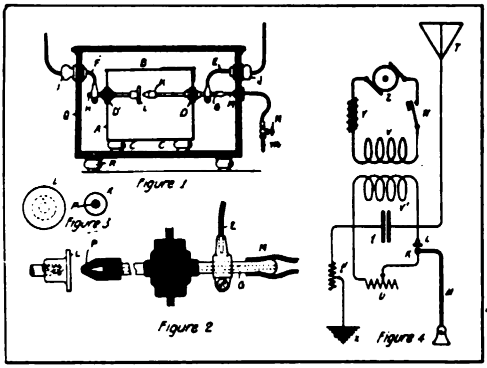


Figure 1—Sectional elevation of spark gap apparatus. Figure 2—Electrodes. Figure 3—Face-end view of electrodes. Figure 4—Diagram of wireless transmitter

An apparatus to change high frequency currents into uni-directional currents has recently been devised by Archibald Shaw, of Sydney, New South Wales, Australia. In his invention, the rod electrode is pierced axially with a fine hole through which gas is forced so as to impinge with considerable velocity upon the opposed face of the other electrode, and if the primary and secondary circuits are in resonance an arc is no longer formed, but the discharge immediately takes the form of a bluish white incandescent blaze of tapered form extending across the gap, and a pulsatory discharge having a very high frequency passes in one direction only.

In practice, a blast of suitable gas under pressure, such as air is used in the gap, the axial jet is made about one sixty-fourth of an inch in diameter at the nozzle, and the pressure is from 50 to 150 lbs. per square inch. With a substantially flat faced electrode of two or more inches in diameter, and a rod electrode of about an inch in diameter formed at the head as a blunt nosed cone, and a gap measuring about three-eighths to a half an inch between the electrodes, as much as 20 kw. can be passed under a pressure of about

28,000 volts. These proportions are highly suitable for the purposes of a high power wireless transmitter.

For this purpose, air pressure at about 110 lbs. per square inch has been found to give very satisfactory results. The length of the gap is varied according to the voltage and the pressure of air employed; for a voltage of approximately 28,000 and an air pressure of 110 lbs. per square inch, the sparking distance is from three-eighths of an inch to one-half an inch. The air pressure should not be increased with the voltage. The best results for wireless transmitters are obtained with voltages approxibating 28,000.

The inventor remarks that such voltage, with the quantity of current necessary for long distance wireless transmission, cannot be used with multiplate gaps of the Lepel type; nor can heavy currents be rectified as may be done with currents of less quantity though high voltage, in point-and-plate gaps such as are frequently used with influence machines.

Experiments have been performed with discharges having a voltage of 60,000, and the length of the gap has been extended to as much as two inches. Flatness of the opposed electrode is desirable, the best economy being obtained with a flat disk upon the face of which the air jet impinges perpendicularly. The electrodes are preferably made of copper or silver; zinc is undesirable as it shows a tendency to pit at the place of impact of the jet. The diameter of the jet should be increased with the power used in the circuit, a diameter of one sixty-fourth of an inch being correct for 2 kw. and slightly more for heavier currents.

In the drawing of figure 1 is a sectional elevation of the spark gap apparatus, figure 2 an enlarged scale sectional elevation of the electrodes, and figure 3 face-end views of the electrodes. Figure 4 is a diagram of a wireless telegraph transmitter in which the spark gap can be employed.

In figure 1 A is a case constructed of micanite or other suitable insulating material and fitted with a lift lid B; it is supported on insulators C, and fitted with leading-in insulators D and D′. E and F are portions of the exciting circuit, their terminals being connected to the stems G and H of the electrodes K and L. The electrode L is fitted with a solid stem H which should be screwed to work in a nut in the leading-in insulator D′ to enable the operator to vary the length of the gap readily. The stem G of the flat nosed cone nozzle electrode K is tubular, and it is connected by a rubber hose M to a source m of air or gas under the necessary pressure. N is a valve in the hose M. The forward end of the nozzle electrode K is coned externally.

In the diagram of figure 4 which represents diagrammatically a wireless telegraph transmitter, Z is an alternator delivering current at about 500 cycles per second. Y is an inductance, W a circuit closing key, and V the primary of a step up transformer. The values in the secondary circuit are proportioned so that the condenser t will break down once in every half cycle of the primary current. The radiator T is construoted to radiate freely at the frequency required for transmission, tuning being effected by adjusting the condenser capacity, the length of the spark gap and the variable loading inductance t′.

Spark Discharger for Radio Frequency Oscillation Circuits

A spark discharger more in the nature of an arc gap has been described by Alfred H. Cohen. The object of the device is to provide a gap that will generate constant and persistent oscillating currents and permit the circulation of a liquid having slight conductivity between the faces of the electrodes in the oscillator. Its construction permits visual examination, at any time, of the operation of the spark discharger between the electrodes and permits the length of the discharge gap to be closely regulated. The inventor states that it is adaptable for use under conditions of constant vibration, sudden

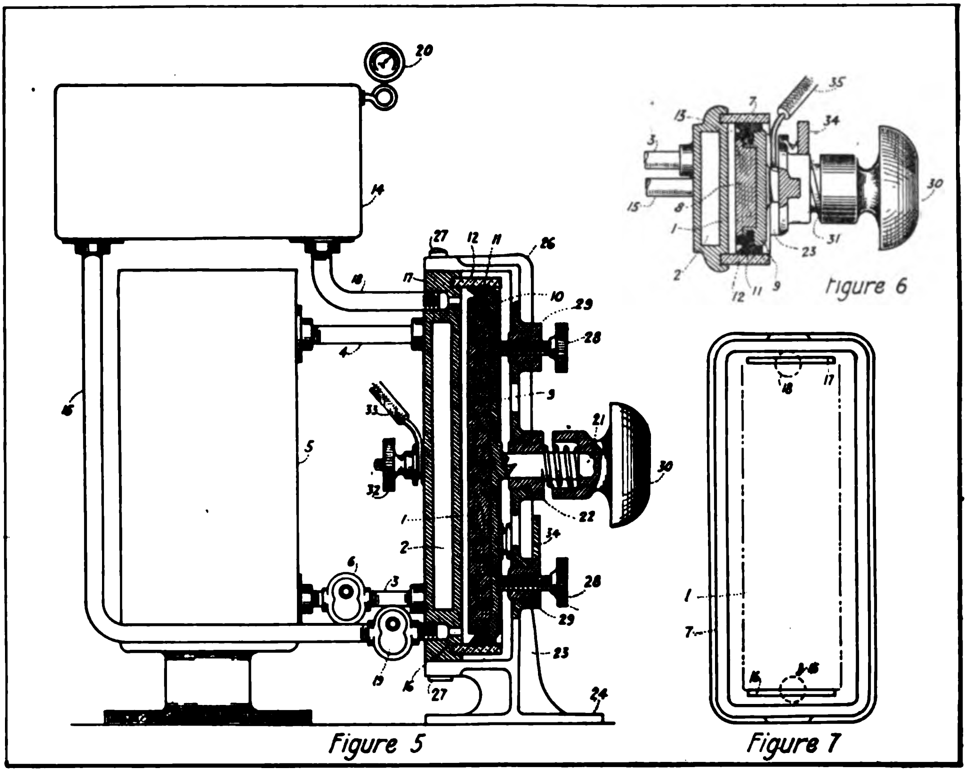


Figure 5—Spark discharger—side elevation and partial cross section view. Figure 6—Cross section of oscillator. Figure 7—Metallic electrodes and ports for circulating liquid between electrodes

shock, change of position and other conditions to be met in marine service, on warships for instance during heavy gun fire.

Figure 5 is a side elevation, partially in cross section, figure 6, of an oscillator constructed in accordance with Cohen's design.

Figure 7 is a detail in front elevation of the metallic electrode, showing the ports for circulating the liquid, between the electrodes.

In detail the construction illustrated in the drawings includes the electrode 1, having a smooth, level plane, sparking surface. This electrode has the hollow chamber 2 cored therein, with which the inlet and outlet pipes 3 and 4 communicate. These pipes are connected with a supply tank 5 filled with a cooling liquid adapted to circulate through the chamber 2 for the purpose of removing the heat created by the spark and radiated by the electrode 1. Thermosiphon circulation is usually sufficient for the circulation of this cooling liquid, but the circulation can be rendered more positive by the addition of the force pump 6. The electrode 1 is surrounded by an annular groove into which the glass ring 7 is cemented.

The electrode 8 is of carbon, coinciding in outline with the active face of the metallic electrode 1. This carbon electrode is embedded in the metallic holder 9, having flanged edges 10 extending to near the sparking surface of the electrode, which has a lateral flange overhanging the thickness of the flange 10. The flange 10 is annularly grooved to receive the packing 11, entirely encircling the electrode 8 and its holder 9, hermetically packing the electrode 8 within the glass ring 7. The attenuated lip 12 of the packing is forced against the wall of the glass ring 7, by the pressure of the liquid confined between the two electrodes and the encircling glass wall of the ring 7.

The space 13 between the electrodes 1 and 8 constitutes the spark gap, which is hermetically surrounded by the glass ring 7. The container 14 is adapted to contain a liquid of slight conductivity such as alcohol, acetic acid, formaldehyde, etc., flowing down through the pipe 15, and through the lower port 16 connected with the space 13, through which the liquid flows upward and out through the port 17, into the pipe 18 connected with the tank 14. The liquid is circulated by the force pump 19, introduced in the pipe 15. To control the pressure of the liquid the tank 14 is pressure tight, and is provided with the pressure gauge 20, properly graduated to disclose the pressure within the tank, or the pressure may be controlled by raising and lowering the tank.

The discharge is started by pressing the knob 30 inward until the electrodes 1 and 8 are brought into contact. This closes the circuit, starting the current flowing through the electrodes, creating a spark as they are separated, the length of the spark increasing as the electrode 8 returns to the normal position fixed by the adjusting screws 28, that regulate the fixed length of the spark for the desired purpose. It is important that this spark travel about, within the confines of the parallel area of the electrodes.

The instant that a spark jumps across the gap 13, the heat generated by the spark creates a bubble in the liquid confined between the electrodes. The point on one electrode from which the spark started, and the point on the opposite electrode to which the spark jumped, are within the bubble for a sufficient period of time to prevent a second spark jumping across between the two exact surfaces isolated or insulated by the presence of the bubble. The succeeding sparks (and they come in succession so rapid as to amount to a practically continuous flow) naturally choose points on the opposite electrodes not occupied by a bubble; therefore, the spark jumps about throughout the area of the opposing faces of the electrodes. The bubbles thus formed very slightly quench each spark as it passes, and prevent the formation of arcs at any point in the spark gap.

The slight conductivity of the liquid allows the sparks to pass between the faces of the electrodes, until it becomes heated at the sparking points, producing the bubbles. The action of the spark is practically continuous, regular and constant throughout the whole parallel surfaces of the electrodes, as is evidenced by the fact that the negative carbon electrode is burned evenly throughout its whole sparking area; this action is facilitated by the constant speed and pressure of the film of liquid passing between the exposed faces of the electrodes. The structure illustrated prevents the forcing of sparks beyond the face of the electrodes, by undue speed in the flow of the liquid, owing to the fact that only the faces of the electrodes are exposed to the liquid. The pressure and the flow of the liquid, therefore, is an important factor in maintaining the correct adjustment.

Advance in the Design of X-Ray Tubes

The Coolidge X-Ray tube, as is well known, operates at extremely high vacua with a pure electron discharge, as contrasted with the Röntgen tubes formerly constructed depending in their action upon the ionization of a residual gas.

In one of the modifications of this tube the cathode rays are focused by means of a static focusing device, such as a ring, tube, or other conductive member surrounding the cathode and establishing a static field radially about the cathode. The focusing member appears to become statically charged by the electron emission of the cathode, and thus modifies the static field in the tube, which is controlling the motion of the cathode rays.

Dr. Langmuir has designed a tube wherein the length of the focus of the cathode rays is varied at the will of the operator, thus controlling the area of the focal spot or surface by adjusting the distribution of potential in the static field directing the cathode rays inwardly to a common point, or outwardly from a virtual focus. For example, by means of a source of po-

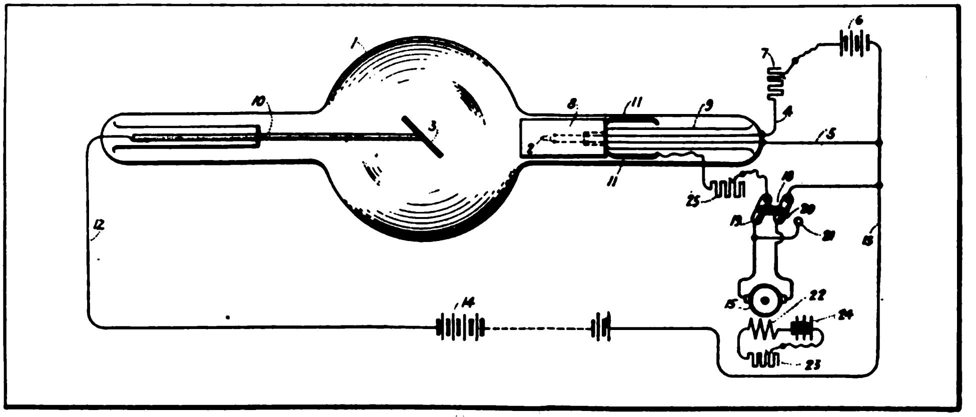


Figure 8—One form of improved Röntgen ray tube

tential between the cathode and the focusing device, the intensity and polarity of the static field may be varied as will now be described:

In the drawings, figure 8 illustrates diagrammatically a Röntgen ray tube provided with a unidirectional source of potential between the cathode and static focusing means; figure 9 shows a Röntgen tube operated from an alternating current source and controlled by a potential which fluctuates in synchronism with the current supply for the tube; and figure 10 shows another means for varying the focus.

Referring to figure 8 it will be noted that the essential parts of the tube comprise an envelop 1 of glass, or quartz, a cathode 2 and an anode 3, located opposite the cathode, and serving also as a focal plate, or focal surface. The cathode, which is a primary source of electrons, consists of a refractory conductor, preferably tungsten. Energy is supplied to incandesce the cathode through leading-in wires 4 and 5 from a battery 6 in series with a variable resistance 7. The anode consists of refractory metal, preferably tungsten. Around the cathode is located a short tube 8 also consisting of metal, for example, nickel, iron or tungsten representing one form of focusing device. The supports for the various parts such as the stem 9 for the cathode, a rod 10 for the anode, and spring anchors 11 for the focusing means have been only diagrammatically indicated. Electrical current is supplied to the tube through conductors 12 and 13 from a source of energy which may be a mechanical rectifier, a high potential battery, or even an alternating current source, such as an induction coil or transformer. The source 14 is symbolic of any of the sources mentioned or their equivalents.

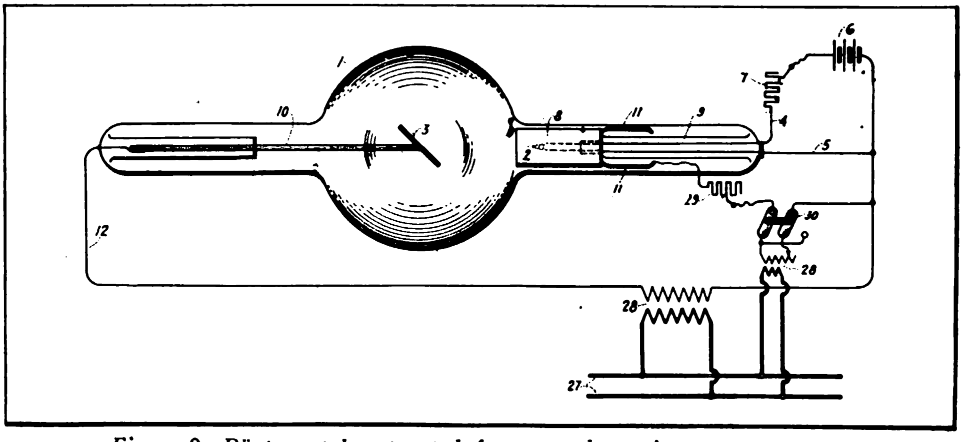


Figure 9—Röntgen tube operated from an alternating current source

(C) Comm. Pub. Info.

How the Signal Corps re-charges its many batteries is disclosed in this view of a charging station for the American Army in France

A source of potential 15 which has been diagrammatically indicated as a direct current dynamo, but may also be a battery, or even a static source of potential such as a glass plate static machine, is connected by means of conductors 16 and 17 and a reversing switch 18 to the cathode and the focusing member. By changing the switch blades from contacts 19 and 20 to contacts 20 and 21, the polarity of the source may be reversed. The degree of potential may be varied in any desired manner, as by varying the excitation of the field coil 22 of the generator, for example, by cutting in or out resistance 23 in the circuit of an energizing battery 24. A resistance 25 is provided in circuit with the source of potential, which may be varied and also entirely short-circuited as indicated.

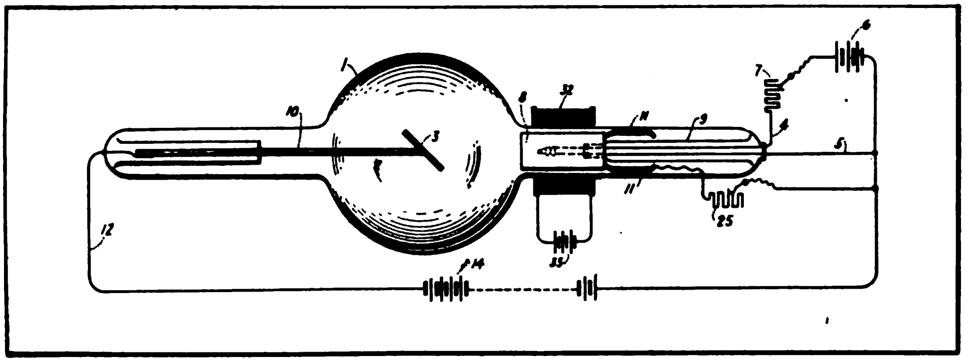


Figure 10—Another form of Röntgen ray tube for varying the focus

When the focusing member 8 is connected to the cathode without interposing any source of potential, one of the surfaces which may be plotted in space to include points of the same potential, will include the tip of the filament and the outer edge of the focusing tube 8. As such equipotential surfaces approach the anode they become less concave. The electrons emitted by the filament when traveling from the cathode to the anode, tend to move perpendicularly to these equipotential surfaces, and are thus directed toward a spot of restricted area upon the anode, called the focal spot.

When the source of potential 15, is introduced into circuit between the cathode and focusing member 8, the positive terminal being connected to the focusing member, the shape of the equipotential surfaces will be changed, as the tip of the filament and the rim of the focusing member no longer are at the same potential. By making the positive potential high enough the focusing of the rays may be entirely prevented, that is, the rays will diverge instead of converge. By making the potential negative with respect to the focusing tube the focal area may be made smaller, or in other words, sharpness of the focusing may be improved. The charge on the focusing member also has an effect on the resistance of the tube and hence on the hardness of the X-rays. A positive charge decreases the hardness and a negative charge increases the hardness in proportion to the potential of the charge.

The structure of the Röntgen ray tube shown in figure 9 is the same as that shown in figure 8, but instead of a direct current source of potential for the focus control, an alternate-source, for example, a transformer 28 is used.

The operation of the system described in figure 9 is similar to that already described in figure 8. Only the half waves of the supply current which are negative with respect to the cathode 2 can pass through the tube. Because of this rectifying property of the tube, the alternating potential between the focusing device 8, and the cathode 2 operates similarly to a direct current source, as it only functionates for waves of like polarity, the set of waves of opposite polarity being suppressed.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XVII

By Elmer E. Bucher

Director of Instruction Marconi Institute

EDITOR'S NOTE—This is the seventeenth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustments of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

ELECTRICAL RESONANCE

(1) In order to secure the maximum range of transmission it is essential that the **open** and **closed circuits** of the radio transmitter be adjusted to substantial **resonance**—that is they must be adjusted to the same nature **oscillation frequency.**

(2) This process of adjustment is called **tuning.**

(3) **Electrical resonance** between circuits of radio frequency is established by resonating circuits which have been calibrated by comparison with a standard or by calculation from knowledge of the inductance and capacity of the circuit.

(4) **Standard resonating circuits** of variable frequency are called **wavemeters.** They should properly be termed **frequency** meters but since a given frequency of oscillation corresponds to a definite wave length in a circuit capable of setting electric waves into motion, the scale of the wavemeter is usually calibrated directly in wave lengths.

(5) The **oscillation frequency** of a circuit containing inductance and capacity can be determined by the following formula:

$$n = \frac{5{,}033{,}000}{\sqrt{LC}}$$

where n = frequency in cycles per second,
L = the inductance expressed in centimeters,
C = the capacity expressed in microfarads.

(6) **The relation between the length of the radiated wave and the frequency of the antenna current** in a radio system is expressed as follows:

$$\lambda = \frac{V}{N}$$

where V = velocity of electromagnetic waves in either (186,000 miles per second or 300,000,000 meters),
N = frequency of the antenna current,
λ = wave length in meters.

Hence if the frequency of the antenna current is equal to 500,000 cycles per second and V $\doteq$ 300,000,000 meters, then

$$\lambda = \frac{300{,}000{,}000}{500{,}000} = 600 \text{ meters}$$

THE WAVEMETER

(1) Any circuit containing concentrated inductance and capacity of variable value, if calibrated in wave lengths, may be called a **wavemeter.**

(2) Modern wavemeters generally have **inductance coils** of fixed value and a **variable condenser.** Some types have a variable inductance and a condenser of fixed capacity. It is generally more convenient, however, to employ the condenser as the variable element of the circuit.

(3) If the condenser is the variable element and the wavemeter is to have an extended range of wave lengths, two or more inductance coils may be supplied.

(4) A scale of wave lengths may be imprinted underneath a pointer attached to the movable plates of the variable condenser or the condenser may have a 180° scale and a table of wave lengths may be supplied corresponding to the angular displacement of the movable plates with the stationary plates.

USES OF THE WAVEMETER

The wavemeter may be employed,

(1) to place two or more radio frequency circuits in electrical resonance;
(2) to measure the wave length of the closed and open circuits of a transmitting set;
(3) to determine the coupling of two coupled circuits;
(4) to measure the decrement of damping;
(5) to calibrate a receiving set;
(6) to measure inductance and capacity.

(2) If the inductance coil of a wavemeter is placed near an active oscillation circuit such as the closed and open circuits of a radio transmitter, radio frequency currents will be induced in the wavemeter. **These currents will attain their maximum amplitude when the frequency of the wavemeter coincides with the frequency of the oscillation generator.**

(3) It is therefore essential that some **current or potential indicator** be included in the circuit of the wavemeter in order that the resonance adjustment of the wavemeter may be correctly determined.

(4) A **milliammeter** or a so-called high frequency hot-wire wattmeter are generally employed as current indicators. As a potential indicator, a carborundum rectifier with a head telephone in series, is favored.

AERIAL AMMETERS

(1) Resonance may be established between circuits of radio frequency by means of an ammeter suitable for high frequency currents.

(2) In certain types of transmitting apparatus such as the standard Marconi panel transmitters, the spark gap circuit is calibrated at the Company's laboratory, the contact clips to the primary coil of the oscillation transformer, being soldered fast in position.

(3) To place the closed circuit in resonance with the aerial circuit, in a set so designed, it is only necessary to vary the inductance or the capacity of the antenna circuit until the aerial ammeter indicates a maximum. A wavemeter is required, however, to determine the **purity** and **sharpness** of the radiated wave.

TUNING THE TRANSMITTER

(1) To tune a transmitter to the International standard wave lengths the following measurements must be taken:

(1) The natural or fundamental wave length of the aerial circuit;
(2) The wave length of the closed circuit;
(3) The length of the radiated wave.

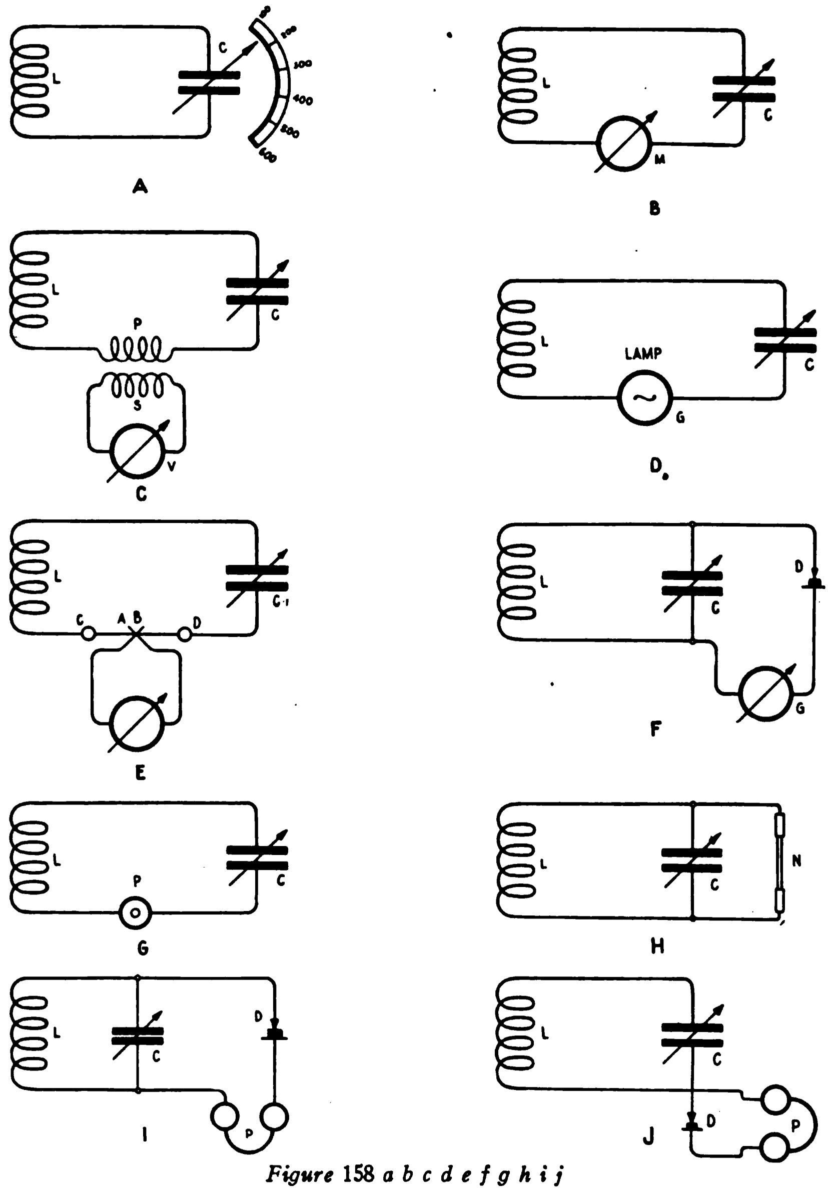


Figure 158 *a b c d e f g h i j*

OBJECT OF THE DIAGRAMS

To show the various devices employed to indicate that the wavemeter is in resonance with the circuit under measurement.

DESCRIPTION OF THE DRAWINGS

In Fig. 158c a small **hot-wire wattmeter** W—range .01-0.1 watts—is connected to the secondary winding S, of a small step-down transformer, the primary P being con-

In Fig. 158c a small **hot-wire wattmeter** W—range .01-.01 watts—is connected to the secondary winding S, of a small step-down transformer, the primary P being connected in series with a wavemeter.

In Fig. 158d, a small **glow lamp** G (2 or 4 volt battery lamp), is connected in series with the wavemeter, the resonant adjustment being determined when the lamp glows brightest (with the wavemeter in a fixed position).

In Fig. 158e, a **thermo-couple** A, B, is attached to a heating wire C, D, the latter being connected in series with the wavemeter. The terminals of the thermo-couple

are connected to a sensitive milli-voltmeter which may be calibrated in milliamperes.

In Fig. 158f, a **rectifying detector** D is connected in series with a galvanometer G, both being shunted across the condenser C. The currents of radio-frequency are converted by the rectifier to direct current and the resonant adjustment is determined by the maximum deflection of the galvanometer.

In Fig. 158g, an **electrostatic telephone** P is connected in series with the wavemeter, the telephone being an active part of the oscillation circuit. The telephone contains a winding of three or four turns placed underneath a copper diaphragm. The maximum sound is obtained when the wavemeter is in resonance with a given oscillation circuit, the copper diaphragm moving with the group frequency of the transmitter.

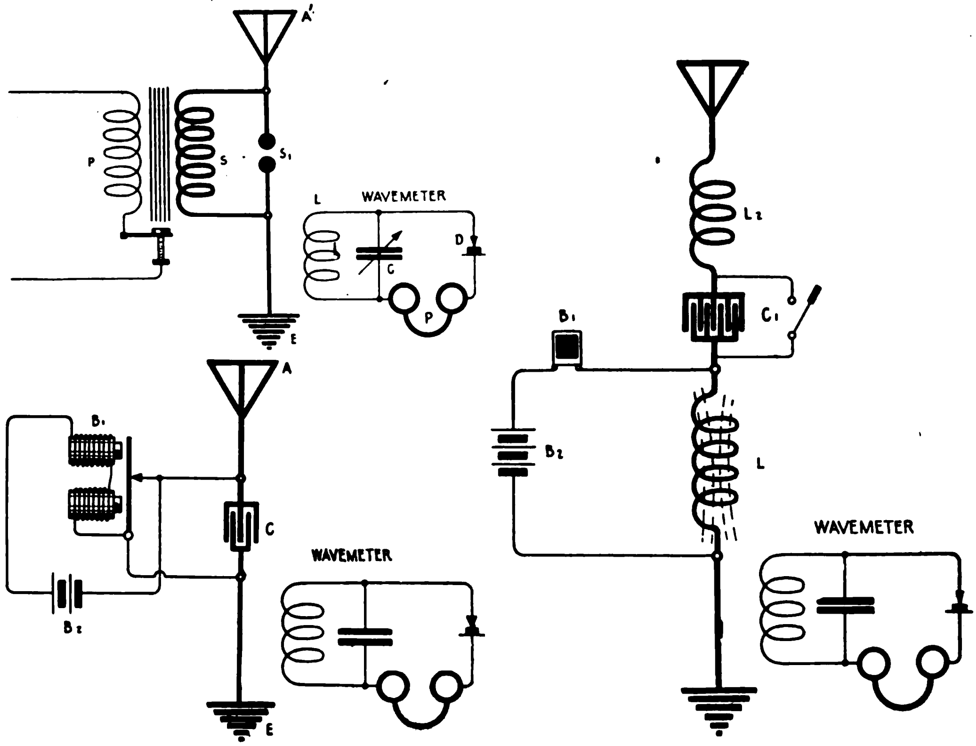
In Fig. 158h, a **tube** N, filled with **neon gas,** has sealed-in terminals at either end. When shunted across the terminals of the wavemeter condenser, the tube glows brilliantly at resonance.

In Fig. 158i, a **crystal rectifier** D is connected in series with a 2,000 ohm telephone P, the final two terminals being shunted across the condenser C. The maximum of sound is obtained in the telephone at resonance. The connection of 158j is often preferred because the calibration of the wavemeter is not affected by the presence of a shunt detecting circuit as in 158i. The uni-polar connection of the detector has the disadvantage that the wavemeter must be placed in closer inductive relation to the circuit under test than with the connection of 158i.

SPECIAL REMARKS

(1) The milliammeter or the carborundum rectifier are generally preferred in practice as resonance indicators.

(2) If feeble radio frequency currents flow in the circuit under measurement, a sensitive oscillation detector such as the three-electrode vacuum tube must be connected to the wavemeter.



Figures 159, 160, 161

OBJECT OF THE DIAGRAMS

To show the process of measurement of the wave length of the aerial circuit in a radio transmitting system, and means for setting the aerial circuit into oscillation.

PRINCIPLE

In order that resonance adjustment of the wavemeter with the circuit under measurement may be determined, the antenna must be set into electrical oscillation.

DESCRIPTION OF THE DRAWINGS

In Fig. 159 the aerial is set into excitation by a spark coil, the secondary terminals of which are connected to the spark gap S-1 connected in series with the aerial. The coil L of the wavemeter is placed in inductive relation to some part of the aerial circuit preferably near the earth lead.

In Fig. 160 a condenser of large capacity C, is connected in series with the aerial. It is in turn shunted across the interrupter contacts of a vibrating buzzer.

In Fig. 161 a small coil, L-1 is connected in series with the aerial system. This coil is also a part of the circuit from the battery B-2 through the buzzer B-1.

OPERATION

Either the spark coil or the buzzer is set into operation. The wavemeter is placed in inductive relation to the aerial system followed by varying the capacity of the wavemeter condenser until resonance is established as may be indicated by one of the well-known resonance indicators previously mentioned.

SPECIAL REMARKS

(1) In the diagram of figure 159 the natural wave length of the aerial is under measurement, but in figure 161 the wave length of the complete open circuit is being taken. Coil L-1 in this diagram may represent the secondary coil of the transmitting oscillation transformer. Condenser C-1 is the usual short wave condenser. L-2 is the aerial tuning inductance. By change of L-2 or C-1 the serial may be adjusted to radiate waves above and below the fundamental or natural wave length.

(2) In figure 160 the capacity of the condenser C is very large compared to the capacity of the aerial and as a consequence it has but little effect upon the wave length of the circuit; but the charge it receives from the counter E. M. F. of the buzzer, sets the aerial into oscillation at its natural frequency.

(3) A high-voltage alternating current transformer may be employed in figure 159 instead of the induction coil but means must be provided to reduce the current output to prevent arcing at the spark gap.

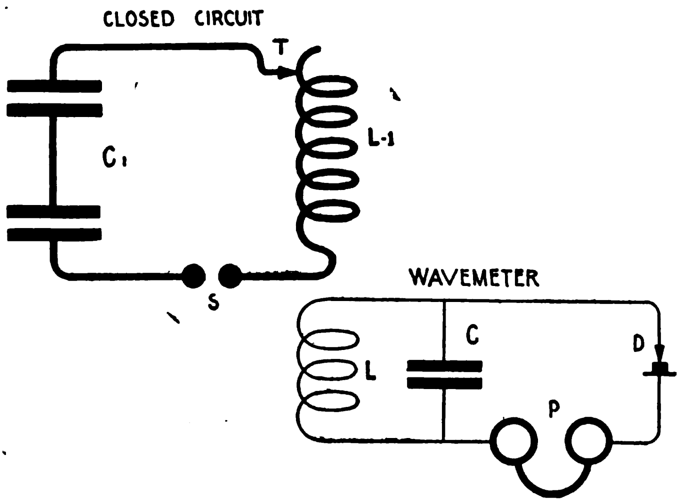


Figure 162

OBJECT OF THE DIAGRAM

To indicate the process of measurement of the wave length of the closed oscillation circuit of a radio transmitter.

DESCRIPTION OF THE DRAWING

The high voltage condenser of the transmitter is indicated at C-1, the primary winding of the oscillation transformer at L-1, and the spark gap at S. The wavemeter is indicated at L, C.

OPERATION

The wavemeter (L, C,) is placed in inductive relation to the primary coil L-1. The spark gap is energized and the wavemeter condenser adjusted until the resonance indicator shows a maximum.

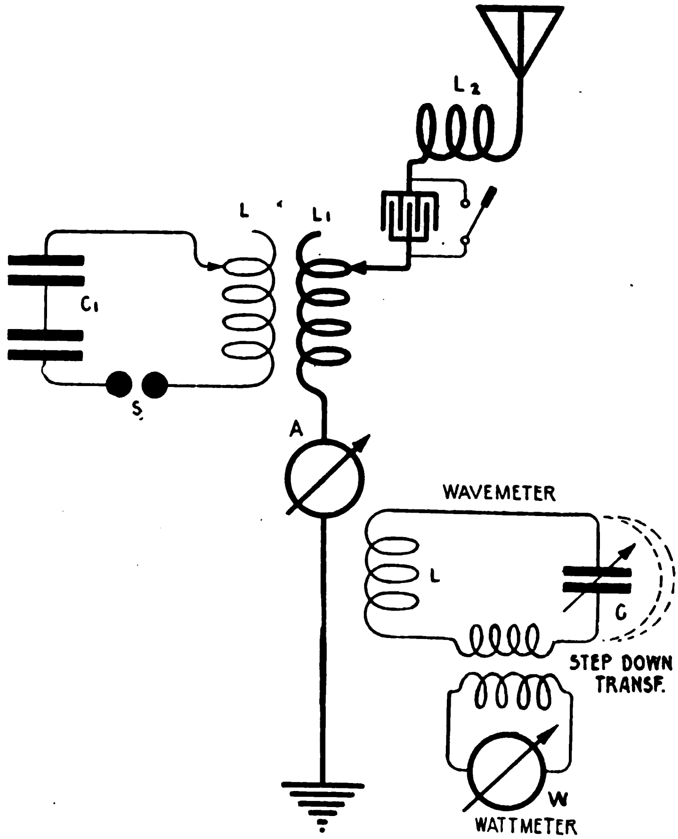


Figure 163

OBJECT OF THE DIAGRAM

To show the connections of the apparatus for the measurement of the radiated wave.

DESCRIPTION OF THE DRAWING

The closed oscillation circuit of the transmitter is indicated by the condenser C, the primary coil L, and the spark gap S. The open circuit or the antenna circuit is represented by the aerial, the aerial tuning inductance L-2, the short wave condenser, the secondary coil L-1 and the aerial ammeter A.

The wavemeter comprises the inductance L and the variable condenser C, and in this particular illustration a low range hot-wire meter W, is inductively coupled to the wavemeter circuits.

OPERATION

It is assumed that the open and closed circuits have been tuned to a definite wave length in accordance with previous instructions. The two circuits are coupled at the oscillation transformer L, L1, the coupling being carefully regulated until the aerial ammeter A indicates a maximum. The coil L of the wavemeter is then placed in inductive relation to the earth lead. The capacity of the condenser C of the wavemeter is then varied until the ammeter W reads a maximum.

If two positions of capacity on the condenser give maximum readings, it indicates that the aerial circuit oscillates at two frequencies. If a single wave emission is desired the coupling of the transformer L, L1, must be reduced until a single resonance position on the condenser C, is obtained. This indicates that the aerial radiates a single wave.

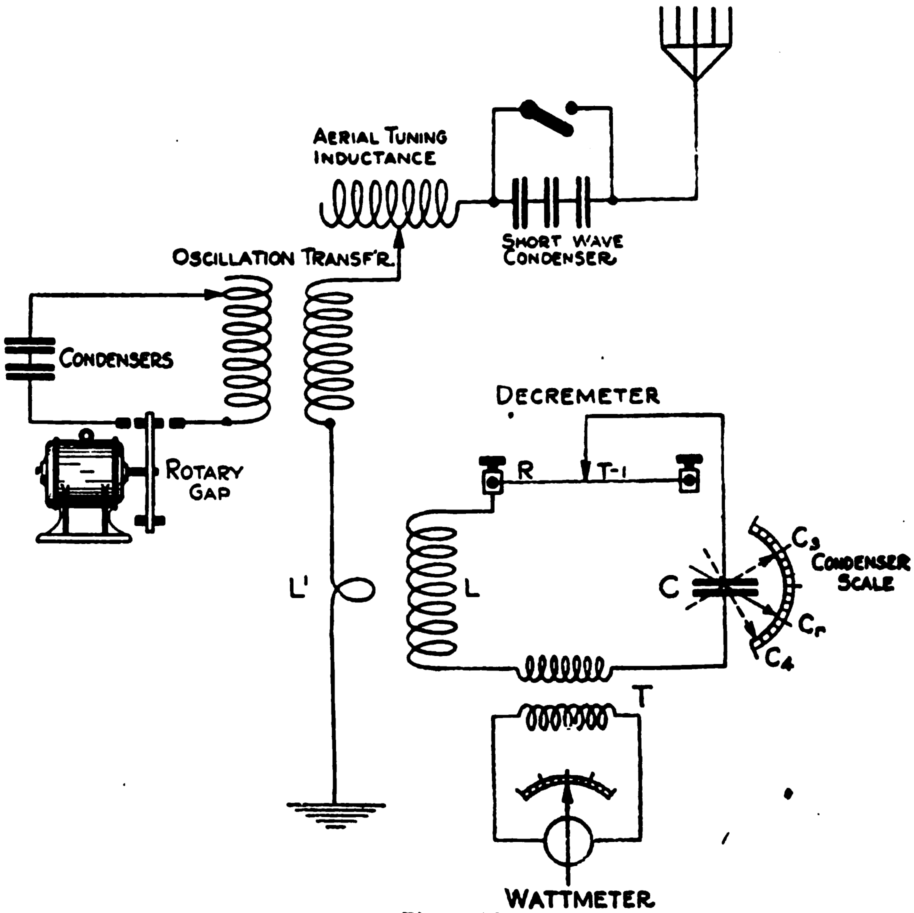


Figure 164

OBJECT OF THE DIAGRAM

To show the fundamental connections of the apparatus for determining the logarithmic decrement of damping.

DESCRIPTION OF THE DRAWING

The open and closed circuits or transmitters are indicated by the usual elements. The coil L of the wavemeter L, C, is inductively coupled in the antenna circuit at the single turn of wire L1. The circuit of the wave meter includes a small step-down transformer and an I^2 (current squared) instrument called a wattmeter.

OPERATION

The measurement of the decrement is based upon the following formula. It is a derivation of the original Bjerknes formula:

$$\delta_1+\delta_2=\frac{C_2+C_1}{C_2-C_1}\times 3.1416$$

Where C_2= the capacity of the condenser C at values above resonance where the reading of the wattmeter is one-half of that obtained at resonance.

C_1= the capacity of the condenser C at points below resonance where the reading of the wattmeter is one-half of that obtained at resonance.

The value of the δ_2 is usually indicated on the scale of the decremeter, or in a table supplied with the decremeter. If not, it can be obtained by the following process:

With the wave meter in the identical position as in the previous measurement, a piece of resistance wire R is stretched between the two binding posts indicated in the drawing. (A piece of No. 28 therlo wire approximately 15 inches in length will be found satisfactory).

Press Ill. Svce.

The Italian retreat is known in military annals for the stubbornness with which the ground was contested. This view shows reserve infantrymen going into action in a ravine under heavy fire

With the pointer of the condenser set at resonance, the spark gap of the transmitter is energized and resistance added at R until the reading of the wattmeter is exactly one-half that obtained in the first measurement. The complete process of the measurement of the decrement is gone through as in the first instance. The decrement is then increased by an amount dependent upon the resistance of R. The following formula is then applicable:

$$\delta_1+\delta_2+\delta_3=\frac{C_4+C_5}{C_4-C_5}\times 3.1416$$

Where δ_3 = the added decrement due to the resistance R,
C_4 = capacity of condenser C at a point above resonance where the reading of the wattmeter is one-half of that obtained at resonance;
C_5 = the capacity of the condenser C at a point below resonance where the reading of the wattmeter is one-half of that obtained at resonance.

The value of $\delta_1+\delta_2$ is now subtracted from $\delta_1+\delta_2+\delta_3$ to obtain the value of δ_3. Letting V stand for $\delta_1+\delta_2$ and V-1 for $\delta_1+\delta_2+\delta_3$, it has been shown that

$$\delta_2=\frac{V\text{-}1\times\delta_3}{2V-V\text{-}1}$$

If the value of δ_2 is now subtracted from $\delta_1+\delta_2$ the value of δ_1 is secured.

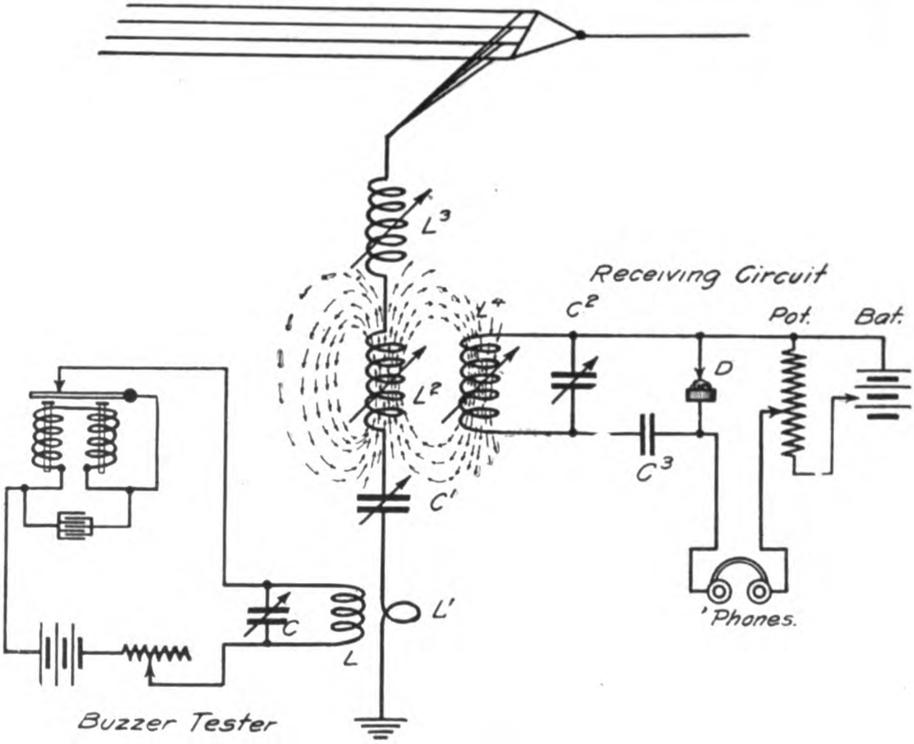


Figure 165

OBJECT OF THE DIAGRAM

To show how the wavemeter can be employed to calibrate a receiving set.

DESCRIPTION OF THE DRAWING

The antenna circuit of the receiving set is indicated by the aerial inductance L-3, the primary winding of transformer L-2, the short wave variable condenser C^1 and the turn of wire L^1 for coupling the aerial circuit to the wavemeter coil L.

The secondary circuit is indicated by the secondary coil L^4, the short wave condenser C^2, the stopping condenser C^3, the crystal rectifier D, the potentiometer Pot. the local battery Bat. and the head telephone.

The wave meter comprises the coil L and the variable condenser C. This circuit is set into oscillation at its own frequency by a buzzer and battery the circuit of which is completed through the coil L.

OPERATION

When the buzzer is set into vibration, the wave meter L, C oscillates at whatever particular frequency it is adjusted to. The coil L acts inductively on the antenna coil L′, inducing therein a small E. M. F. The antenna circuit or receiving set is then set into oscillation at this frequency, but the maximum response will be obtained in the head telephones when the antenna and detector circuits of the receiving set are adjusted to exact resonance with the wave meter.

In this way a receiving operator can properly adjust his apparatus to any definite wave length.

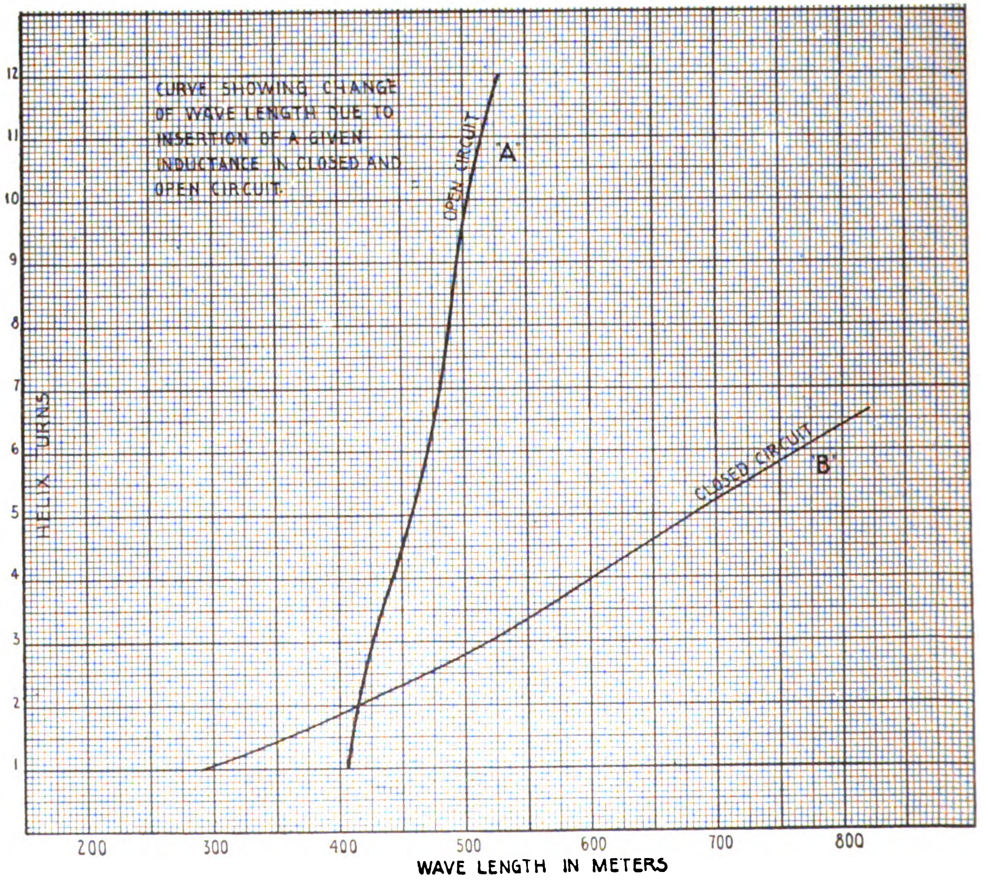


Figure 166—Curves showing the increase of wave length in the open and closed circuits of a transmitting set occasioned by the increase of inductance in either circuit. Curve A shows the increase of wave length in the antenna circuit by the addition of 12 turns of the secondary winding of a standard oscillation transformer. Curve B indicates the increase of wave length in the closed circuit by the addition of 6½ turns at the primary coil. This data is obtained by observing the readings of the wave meter in inductive relation to either circuit as the inductance is increased. The open and closed circuits are generally uncoupled for this determination, the antenna circuit being set into excitation by a spark gap or by a buzzer.

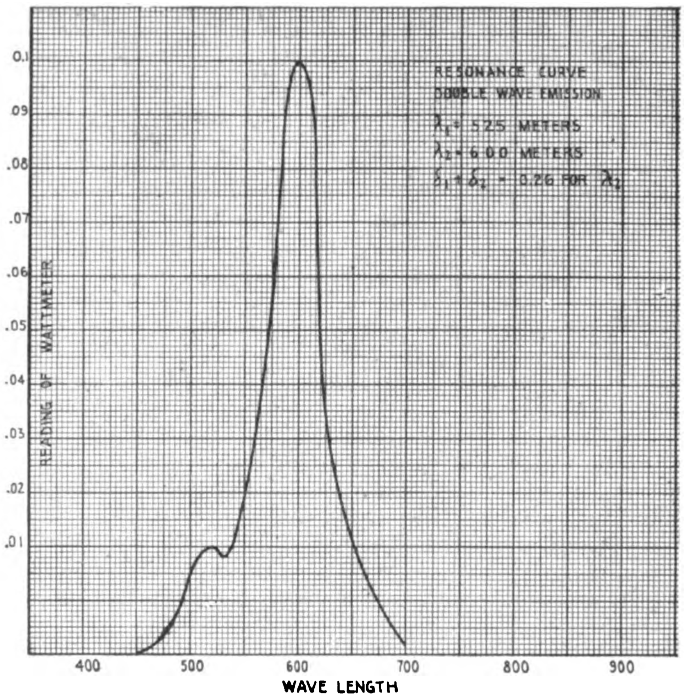


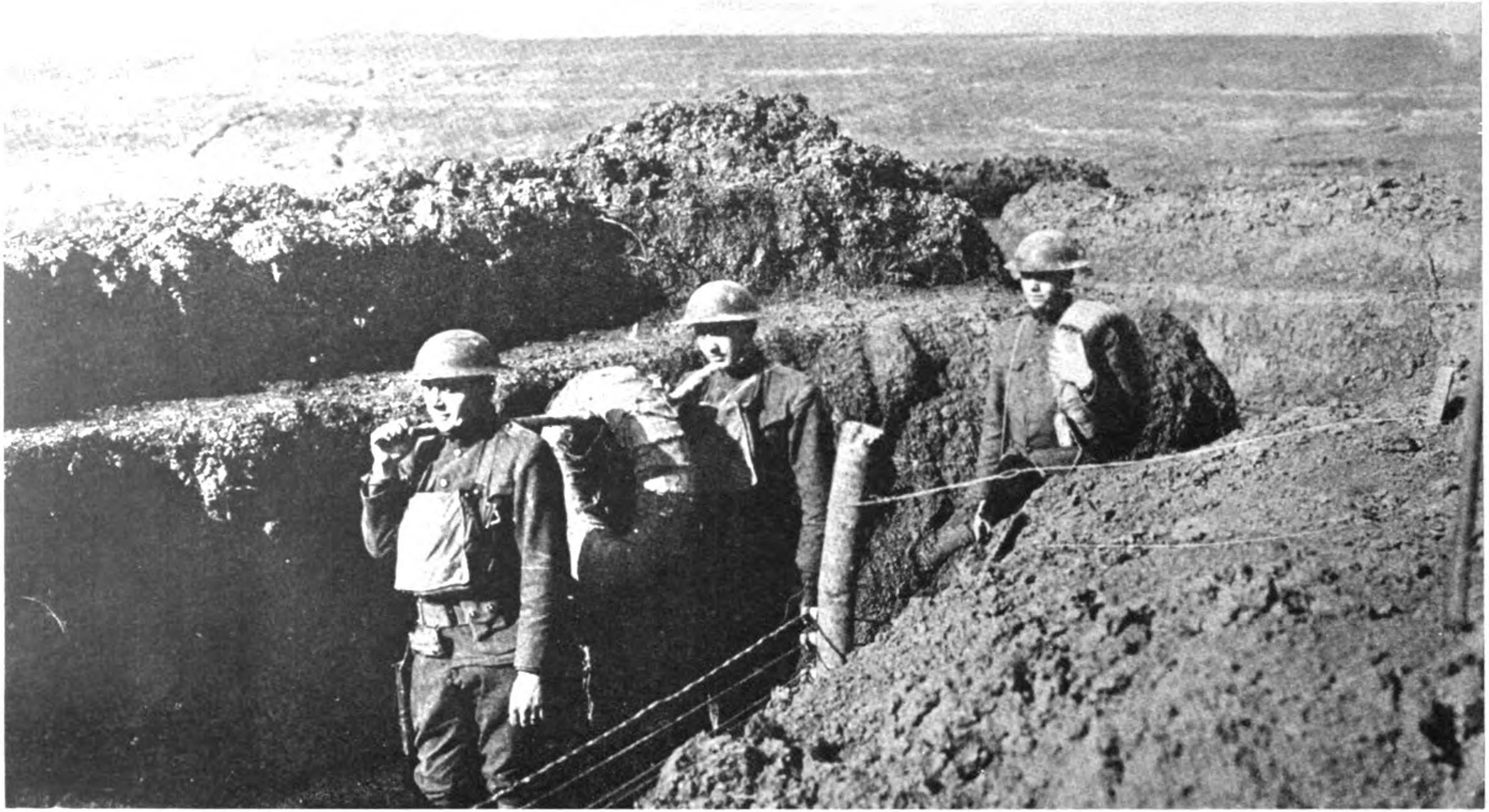
Figure 167—Resonance curve of the radiated wave of a radio transmitter, which complies with the U. S. regulations. The curve indicates that the antenna oscillates at two frequencies, one corresponding to a wave length of 600 meters, and the other to a wave length of 526 meters. The amplitude of the shorter wave is one-tenth of the longer wave and hence it meets the requirements of the U. S. Statute. Modern transmitters are generally adjusted for a single wave emission.

October Features

An article describing the Harvard Radio School where five thousand men are being prepared for the Navy.

An article describing Langmuir's method of constructing gas-free electrodes for Vacuum Tubes and another article on a method of preparing the Three-Electrode Vacuum Tube.

A novel Vapor Arc Generator for the production of radio frequency currents is an additional feature.



(C) Comm. Pub. Info.

Through acres of sun-baked mud these American Signal Corps men daily carry forward coils of new wire for the signaling systems of the trenches. In the view above they are passing from the support to the first line trenches

Signal Officers' Training Course*

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

By Major J. Andrew White
Chief Signal Officer, American Guard

SIXTEENTH ARTICLE

Signal Troops in the Field

IN defining the exact duties of Signal Corps in the field it may be said that it exists for the speedy dissemination of military information. It is the nerve system of the army by which information is transmitted to the brain. Unlike other branches of the service there are no fixed rules for its operation which could be condensed into a tactical manual such as exists for other fighting units.

An official bulletin from the office of the chief of staff, U. S. Army, deals with conditions in field service by stating that the Signal Corps is specially organized, trained, and equipped for the collection and transmission of military information, and only the most general instructions should be given to officers and men as to the manner of performing their duties. It is inadvisable, especially in brief field orders, to attempt detailed instructions; it will suffice in such orders to state the commands to be joined, their location, and a broad statement of the object desired. It is assumed that the signal officer, acting under his general instructions and the orders of his immediate commander, possesses the knowledge, the initiative, and the energy to meet conditions as th y arise.

The signal officer at headquarters, in addition to caring for the technical administration and supply of the signal troops, will keep himself informed as to the location of commands, the time and character of projected movements; in short, regarding all actual and probable happenings, so that he may make due provision in advance. He must arrange for the prompt transmission of information received, and for the delivery of all messages. He also makes certain that the military intelligence contained in messages to the commanding general and chief of staff is properly recorded on the map or otherwise graphically so as to be instantly available, and for this purpose

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

should establish a central station at division headquarters, equipped to properly file all messages sent and received, in chronological order and by organizations. This station should also be able to furnish at all times exact information, as to signal stations and location of troops.

The commander, aided by his chief signal officer, must plan and direct, but the signal officers and the men under thm must execute; on their energy and ability will depend the value and success of the lines of information.

Establishing Lines of Information—The Division

Since the Signal Corps is considered as auxiliary troops attached to a division it is best to define its field duties in this connection. While definite rules cannot be laid down for the establishment of lines of information for a division in the field, there are certain fundamental considerations or general principles to be observed.

The division may be considered under three conditions: in camp, on the march, and in contact with the enemy.

When a division is to be assembled in a certain locality and camp established, an officer is sent ahead to select sites for the encampment of the various units of infantry, cavalry and artillery. Quartermaster officers locate their depots and medical officers the field hospitals. It is then the duty of the signal officer to proceed with the installation of lines of information.

A wireless, or radio set, of the cart or tractor type travels with division, corps and army headquarters and is first put in commission. A central station is next established at division headquarters and connected with the most convenient telegraph and telephone offices through which communication may be established with commercial systems or the base.

The Signal Corps camp is then established with a depot for storing all material needed for the service to be required. Corps or army headquarters are connected by wire or radio, telephone lines carried to the chief quartermaster and surgeon and the various hospitals, depots, and corrals.

The object to be attained is the connection of every important point with division headquarters, to link the whole command together and connect with the base by wire or radio. As the various units arrive at their camps, telephone or buzzer lines are run from division central to brigade headquarters, through regimental to battalion headquarters.

Between fixed stations within the limits of the divisional camp the telephone is the ordinary means of communication, telegraph and radio being reserved for more distant work. Telephone and telegraph lines are usually carried by lances. In addition to the more permanent lines, temporary buzzer or field wires are usually laid to changing positions, such as outlying observation points, to the outposts and to aero stations.

In camp there should be little difficulty in using fully the lines of information, since the extent and direction of the system are known and the stations are easily found. On the march, however, the lines of information become fewer and the stations more difficult to reach. Some general considerations may be noted.

A division on the march must at no time lose electrical connection with its base, through the last station occupied, and for this purpose the pack radio is especially useful. As the advance continues the commanding general designates some position as his own during the day or night and lines are

Sample of telephone dug-out in the front line trenches in which the Signal Corps men maintain the lines of communication at all hazards

extended forward or communication is maintained by radio with this position, it becoming, so far as the lines of information are concerned, the headquarters.

As radio stations, the buzzer, or field wire advance they should be followed, if practical, by the telegraph train with the necessary material for a lance line to replace the field or buzzer wire, which, if exposed, is liable to injury from passing troops and transport. At times, with good roads and open country the advance is so rapid where a lance line is being erected by trained men, that little, if any, cable need be used on the march. Buzzer wire may follow the general line of advance of the commander by extending from one conspicuous station to another designated by him. The field line, or radio, is used only for rapid work. Radio, when used on the march, is advanced by the leap-frog method; that is, three sections are used, the rear station passing the two preceding and thus constantly maintaining two stations in operation.

In the advance the units of a command should, so far as possible, be kept in touch with each other; but as these units frequently move by different routes, and as cross lines are impracticable except at halts, field or buzzer wires must stretch from the last field station maintained at the rear to corps headquarters, and to brigade and to important commands, as the ribs of a fan expand; here, too, the radio must be used. If possible, wire communication between the general and detached commands, or cavalry at the flanks, is also maintained in this way, or communication established by means of visual signaling or radio. Visual signaling may be used to advantage during halts when wire lines can quickly be thrown out; and radio, especially of the wheel type, is particularly useful.

When the day's march is over and the division eats and rests, the work

of the signal men begins anew. Radio stations must be established and buzzer lines run from the advance guard, from the flank, from the corps headquarters, and from the rear to division headquarters, and still others laid out as already described in a preceding paragraph.

When a retiring movement is begun the lines of information are as few as possible and mainly used to connect the rear guard, probably by radio, with the general commander. Provision is made, however, to recall the flanking parties thrown out at intersecting roads when the rear of the marching columns pass. It is well also to connect retreating columns moving by different roads, and this can be done by wire and radio more readily than in the advance, since lines extending to the front of the retreating force will not ordinarily be in danger of interruption. In the retreat, therefore, central stations may be thrown out far ahead and wires led back like the ribs of a fan to the marching column, as in the advance, to be taken up as the columns pass.

As the period of actual contact with the enemy approaches the most serious of the problems of the lines of information arise. The general commanding must know the terrain and the best means of sending messages across it; he must know the probability of success of the attempts of the enemy to cut the wires, or "jam" a radio, and it is when difficulties arise that every possible means of signaling that offers a chance of success is employed.

As the division approaches the enemy, the commander makes as certain as possible that his lines of information with corps and army headquarters, with supporting and reserve troops, and with the rear, are in order and when actual contact comes, buzzer lines will be carried to brigades, to regiments, and sometimes to the outposts. For the troops engaged, buzzer lines are carried forward to the firing line, where trained observers with buzzers or the field telephone are placed to send back important information for control of fire.

It may be practicable at the beginning of the action to maintain touch by radio or even by wire between the smaller reserves, the supports, and the main bodies, but the latter is doubtful, since a great multiplicity of wires on the field of battle is hazardous.

When the division is actually engaged against the enemy the commander extends his field or buzzer line to the positions occupied by the infantry and artillery commands. Radio is in general depended upon to keep him in touch with his cavalry. The artillery, in addition to its other lines of information, establishes between batteries a system of fire control, the information being transmitted from fixed stations, captive balloons or airplanes, by radio, field telephone or buzzer, or by visual signals.

The radio is of greatest importance in the field and especially when used at the larger headquarters. Together with the increasingly greater use of the field telephone in directing the fire of heavy artillery, the large scope of the tactical requirements in modern warfare has enormously increased the work of the Signal Corps.

Communication problems are easier with the smaller bodies of troops, but not less important. When operating in an enemy's country, especially if the movements are connected with a boat expedition or with the navy, somewhat less weight must be given to wire communications, and more reliance be placed upon visual signaling and on the portable radio units. With all such expeditions the field acetylene lantern is extremely useful, for its range under favorable conditions is easily 20 miles, and it can be used by hand from a boat if on quiet water.

Signal Corps News

Production Experts Wanted

Urgent calls have been issued by the Signal Corps of the army for twenty production experts for important war work. These places are under the Civil Service, and command salaries ranging from $2,400 to $3,600 a year. The duties consist of supervising, distributing, and expediting the manufacture and delivery of materials and equipment.

Written examinations will not be required for these places, but they will be filled under the Civil Service rules on a non-competitive basis. The Signal Corps desires applications from men who have a general knowledge of production and manufacturing problems, experience in preparing and maintaining charts and data of progress, and preferably a thorough knowledge of the manufacture of radio, telephone, or telegraph material and equipment, with all the tools and apparatus pertaining to such equipment and its installation.

Applications will not be received from employes of the Government or of firms or corporations engaged in carrying out contracts for the Government or its allies, unless accompanied by the written assent of the head of the office by which the applicant is employed. Application blanks and full details may be obtained by applying to the Secretary, Second Civil Service District, Room 319, Custom House, New York City.

Students' Army Training Corps

The Public Relations Committee of the War Department, Committee on Education and Special Training, authorizes the following: A trained reserve Army of 100,000 young men volunteers between the ages of 18 and 21 years, to be held in readiness by the universities of the country, is expected as the result of the present "Keep-the-boy-in-college" campaign. This campaign is now being conducted by the schools in co-operation with the War Department.

This national organization is known as the Students' Army Training Corps. It is a recognized unit of the National Army. The college student of the proper age and physically fit is eligible for voluntary enlistment. The student soldier will have the status during the school year of a private in the National Army on furlough without pay. The Government provides uniforms and equipment. During the six weeks of intensive military instruction during the summer a student soldier will receive the pay of a private.

The members of this student army will hold themselves in readiness to respond at once to a call for service from the President. The policy of the Government in urging the "Keep-the-boy-in-college" campaign is to prepare the Students' Army Training Corps to meet future demands for highly trained specialists and to furnish material for officers' training camps.

An Opportunity for Radio Mechanics

The department of military aeronautics, radio section, requires men with some mechanical training, and thoroughly grounded in electrical work. Men will be accepted for this service in the army who are of draft age, and in good physical condition. They will be sent to a school for radio mechanics, and afterwards will go overseas at the first opportunity. There will be many opportunities for advancement, and the work is most interesting. About 130 men are required at once, and it is desired to build up a reserve force of several hundred men.

The following men have recently been commissioned:

Weston W. Goodnow, first lieutenant, Aviation Section, Signal Reserve Corps.

Wendell G. Greening, first lieutenant, Aviation Section, Signal Reserve Corps.

Edwyn Johnstone, first lieutenant, Aviation Section, Signal Reserve Corps.

John W. Koontz, first lieutenant, Aviation Section, Signal Reserve Corps.

Charles F. Moore, first lieutenant, Aviation Section, Signal Reserve Corps.

William H. Royle, first lieutenant, Aviation Section, Signal Reserve Corps.

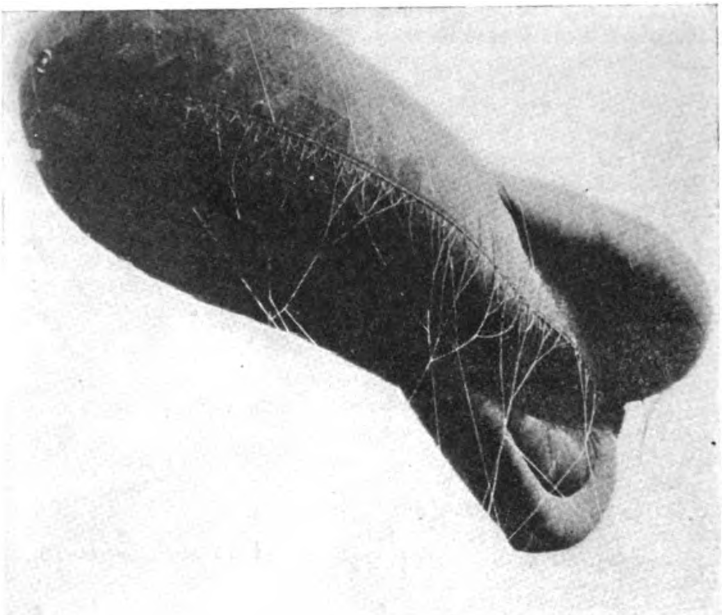
Harry A. Schlotzhauer, jr., first lieutenant, Aviation Section, Signal Reserve Corps.

Robert S. Stewart, first lieutenant, Aviation Section, Signal Reserve Corps.

Frank B. Tyndall, first lieutenant, Aviation Section, Signal Reserve Corps.

Jess B. Wadsworth, first lieutenant, Aviation Section, Signal Reserve Corps.

Frederick L. Walker, first lieutenant, Aviation Section, Signal Reserve Corps.

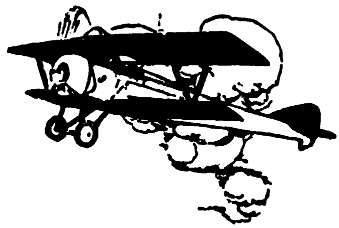


(C) Comm. Pub. Info.

Men of the Signal Corps are here seen getting ready for an ascension in a giant observation balloon used by Uncle Sam's fighters in France. The type shown is known as a kite balloon, a captive bag which will operate safely under almost any weather conditions. The lower bag which is suspended from the main structure is the air rudder, the smaller one just above it is the ballonet, an interior air bag open to the rush of the air. Stabilizing bags are attached to the main structure, which is inflated by hydrogen gas before the ascent. The craft is anchored to the ground by cable and windlass, located in friendly territory. These kite balloons serve mainly as fire control stations, but the observers assigned to them are accomplished lookouts and scouts. Protection is afforded by friendly anti-aircraft guns and airplanes, which beat off all hostile attacks

How to Become an Aviator

The Fourteenth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Airplane Design, Power, Equipment and Military Tactics



By J. Andrew White
and Henry Woodhouse

METEOROLOGY FOR THE AIRMAN

IN many ways the air is comparable to the sea; in fact, in a large portion of the study of the basic principles of aerodynamics the action of the sea is used as an analogy. The professional pilot of water craft who lacks knowledge of the ocean is unheard of; and so must it be with the military aviator's knowledge of the air. Successful flying over long periods is largely due to an aviator's understanding of the air and its vagaries; in fact, where this knowledge does not exist, continued success is entirely a matter of luck. Some grasp of the elementary principles of meteorology is therefore essential. It may be gained by experience, but this method has more than once led to fatal misconceptions. Theoretical instruction, through which ability is acquired to apply the scientific laws of weather forecasting, is a safeguard well worth the time spent in acquiring it.

The best weather for flying is obtainable on a calm, clear day, when eddies or vertical currents are not likely to be encountered. A strong gale is about the only condition that makes flight impossible to the modern airplane, although fog is a considerable handicap to military flying, by reason of the poor chances for proper observation.

A ground haze, low lying clouds, and location of the sun dead ahead, also impede useful military flight, as do detached clouds; but none of these prevent the aviator going aloft. Air eddies and ascending or descending currents, too, are seldom so violent that flying is seriously interfered with. For students engaged in first flights, the early morning and evening are the most suitable times, for it is then that the air is calmest. In the United States, winds from the east and southeast carry with them less "bumps" and are most favorable.

CHARACTERISTICS OF THE AIR

COMPOSITION OF THE ATMOSPHERE

Air is a gaseous body, which, like water, seeks the level where lowest pressure exists. It is 1,600 times lighter than water, but it is at least 50 miles deep, and since one-half of its weight is below 3 miles altitude, its weight or pressure at the earth is considerable. Its constituents are: nitrogen, 70 per cent.; hydrogen, 20 per cent.; argon, 1 per cent.

ATMOSPHERIC PRESSURE

The weight of air on a given spot is atmospheric pressure. The longer the column of air above the place, and the greater the density of the air, the greater will be the pressure at the bottom of the column.

Pressure is variable, however. The temperature of the air usually decreases with height at a rate of about one degree for every 300 feet. This rule is not an absolute one, since temperature varies with locality and season of year, but is useful as a general guide. Density of the air is affected by temperature, due to the expansion of heated air and contraction of cold; density is also affected by pressure, for the higher the air column the greater the air contained in a given space at the bottom.

Air at rest is given motion by change in temperature at the earth. For example, heat from the sun's rays is not absorbed uniformly, bare earth heating more rapidly than portions covered by trees and grass. Over the bare spot the heated column of air will rise by expansion, and as it rises the pressure there will be diminished, whereupon the cooler surrounding air will rush into the vacated space. As the operation is repeated the air motion increases. Thus elevations and depressions are formed, or, as they are termed in meteorology: HIGH PRESSURE AREAS and LOW PRESSURE AREAS.

MEASURE OF PRESSURE

The barometer is the instrument used to measure air pressure. It is measured by the height, in inches, of a column of mercury necessary to balance it. At a fixed time each day atmospheric pressures taken at various stations scattered over the country are telegraphed to the meteorological office and a weather map is made from those reports. Such a map is illustrated in figure 82.

By joining places which register the same barometric pressure, lines are formed similar to map contour lines and known as *isobars*.

PRESSURE AREAS

All places on any line (isobar) have the same atmospheric pressure; where little difference of pressure exists at places close together, the isobars will be close together, and vice versa. The air forced from high pressure to an area of lower pressure does not follow a straight line, but takes a spiralling course in a direction more nearly parallel to the isobars than at right angles. This is due to the irregularities of the earth's surface and the revolution of the earth on its axis.

Pressure areas, which usually have a diameter of hundreds of miles, do not remain in the same position, examination of U. S. weather maps for successive days showing that they ordinarily move in a general easterly direction and occasionally north and south, but westward only in hurricanes.

An unusually small pressure area indicates a *cyclone area* and sudden violent changes in weather may be looked for. In a high pressure region, or *anti-cyclone,* the weather to be expected and the indications are almost the reverse.

Since the winds flow spirally about the pressure areas, the isobars on the weather map furnish the aviator information as to the general direction of the wind, knowledge which is extremely valuable if a cross-country flight is contemplated.

CYCLONE (LOW PRESSURE AREA)

The winds blow anti-clockwise about the center of pressure (clockwise in the southern hemisphere). The barometer falls with the approach of the cyclone, beginning to rise again after the center of the area has passed. The front of the depressed area usually holds rain or cloudiness, the rear cooler weather and clearing.

ANTI-CYCLONE (HIGH PRESSURE AREA)

An anti-cyclone has no general direction of motion, in fact it is frequently stationary for days. The winds spiral clockwise from the center and are very light. Almost any type of weather may be expected except heavy winds. Ordinarily, the weather is fine, but in cold weather fog and low lying clouds are frequent, and rain occasional.

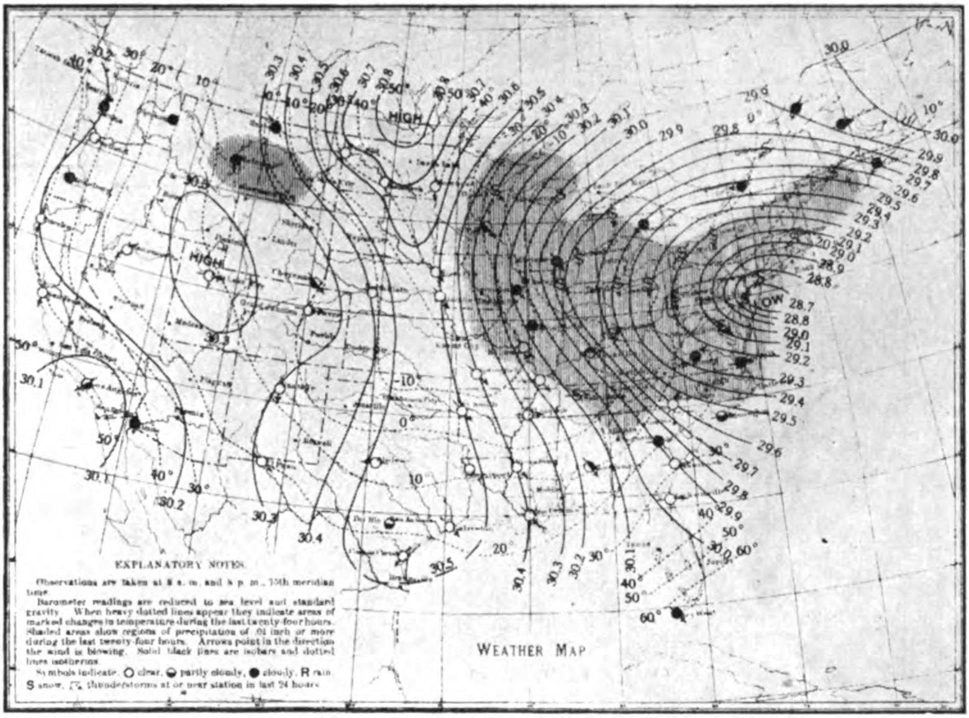


Figure 82—Meteorological map showing atmospheric pressures

SECONDARY DEPRESSIONS

Irregularities in the form of indentations in the isobars frequently appear in a cyclone area. These secondary formations may or may not be well defined; if marked, the winds may become very strong and the weather bad. In front of the secondary the weather is similar to the cyclone, between the secondary and main depression the winds are light, but very strong on the side furthest from the center of the cyclone.

THE WEDGE

When a series of cyclones pass across country in continuous succession, V-shaped isobars appear between cyclones. These indicate fine clear weather, but of short duration, as another cyclone is approaching.

LINE SQUALLS

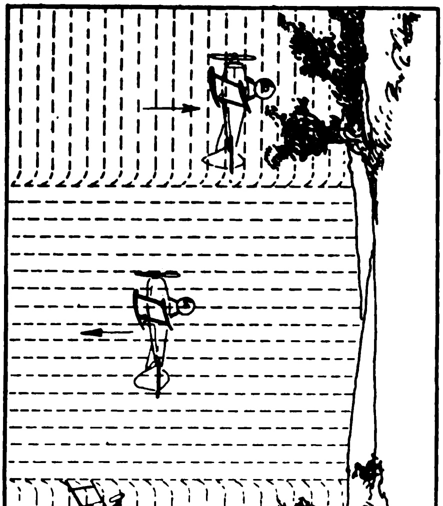
As the center of a cyclone passes line squalls often appear. They are usually very narrow but often 500 miles in length, are very sudden and violent and, traveling approximately at a right angle to their length are very dangerous to airmen. The barometer shows a small sudden rise, and a fall in temperature is noticeable; often heavy rain and hail set in, and, occasionally, thunder. These squalls seldom give any warning and are therefore particularly dangerous.

BEAUFORT SCALE

Wind strength is generally expressed as velocity in miles per hour. For convenience winds are divided into 12 groups or classifications, a system known as the Beaufort scale.

BEAUFORT SCALE

Division Number	Nautical m. p. h.	Description of Wind	Division Number	Nautical m. p. h.	Description of Wind
0	Less than 1	Calm	7	28—33	High wind
1	1— 3	Light air	8	34—40	Gales
2	4— 6	Slight breezes	9	41—47	Strong gales
3	7—10	Gentle breezes	10	48—55	Whole gale
4	11—16	Moderate breezes	11	56—65	Storm
5	17—21	Fresh breezes	12	Above 65	Hurricane
6	22—27	Strong breezes			



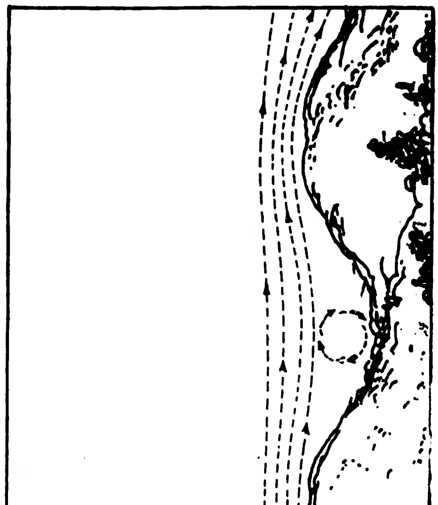
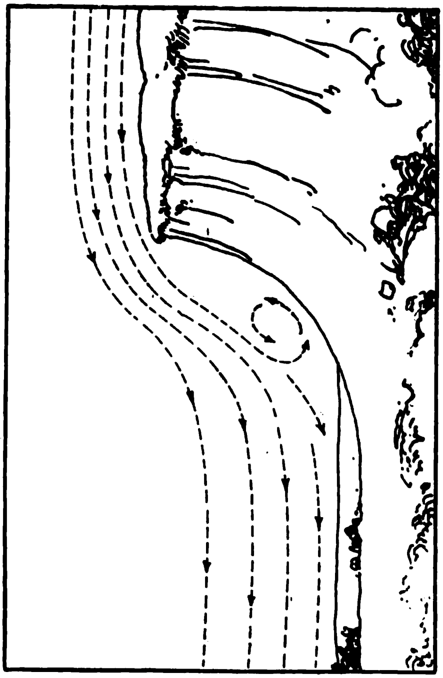


Figure 83 (Upper)—Action of the aerial fountain
Figure 85 (Lower)—Vertical wind eddies below hill crests



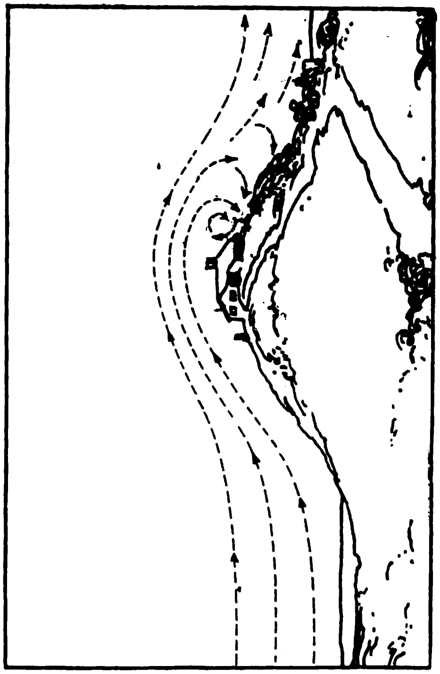


Figure 84 (Upper)—Action of the surface cataract
Figure 86 (Lower)—Eddies, or bumps, in lee of obstacles

WIND CONDITIONS WHICH AFFECT AVIATION

WIND

The aviator does not need to study the cause of wind, but he should know something of its distribution. Wind is stronger by day than by night at the earth's surface; its average velocity in the United States is 11 miles per hour, normally increasing with altitude up to 1,000 feet, above which height it "veers," or goes round in a clockwise direction.

The following scale is useful for calculating wind problems:

At 1,000 feet wind velocity increases 1½ times, with 10 degree veering
At 2,000 feet velocity doubles and wind veering is 15 degrees
At 3,000 feet or over there is practically no velocity increase and veering is constant at 20 degrees.

AERIAL FOUNTAIN

A rising current of atmosphere encountered over barren land and conical hills in warm weather, the air column rising because it is heated beyond the temperature of the surrounding air. These fountains are not ordinarily dangerous but the rate of ascent has been known to reach a velocity of 25 feet per second. The airplane will rise involuntarily if caught squarely by one of these columns, dropping as it emerges. Wing tips will be tilted if the aerial fountain is grazed. See Figure 83.

AERIAL CATARACT

Descending cold air causes a current which takes two forms (a) the reverse of the aerial fountain with opposite effect on airplanes, and dangerous only in thunder storms; (b) surface cataracts developed by steep barren slopes of earth. The action of the surface cataract is shown in Figure 84. Landing should never be attempted in a surface cataract.

AERIAL CASCADE

The bounding air at the bottom of a steep fall over an earth contour is similar to the result with a water cascade. Eddies of a treacherous character are set up, and counter currents, above which the aviator must remain for safety.

AERIAL BREAKERS

Strong cross currents form choppy winds with action similar to ocean breakers. These are generally heralded by corrugated clouds and are to be noted as difficult of navigation by air pilots.

VERTICAL WIND EDDIES

Below the crest of hills wind eddies form, which describe circles in the vertical plane. See Figure 85. Should the aviator be caught in the pocket under a hill the airplane should be headed in and a landing made parallel to the side of the hill.

WIND LAYERS

Wind will very often be found blowing in different directions and velocities at different heights. Although horizontal, passing from one layer to another of different speed and different direction momentarily changes the bouyancy of the airplane, causing the machine to rise or fall. Turbulent motion and a few bumps will only be experienced, and wind layers are therefore not ordinarily dangerous.

WIND BILLOWS

These are horizontal billows similar to ocean waves and occur at the surface between wind layers; rough going, not necessarily dangerous, results.

WIND GUSTS AND EDDIES

These are generally known in aviation parlance as "bumps." Obstacles in the path of moving air at the surface cause them. They are strongest on the leeward side of hills, buildings, or other elevations, and most noticeable in a strong wind. Figure 86 illustrates the action of the air. If landing is forced, the aviator should select the windward side of the obstruction or a point well away to leeward.

AERIAL TORRENTS

The aerial torrent is caused by air colder than the surrounding air pouring downward. Great velocity is attained on surface slopes or open valleys. The effect on the airplane is exactly opposite that of the aerial fountain illustrated in Figue 83.

Figure 87—Cirrus (Mare's Tails), altitude 30,000 feet or more. Predict wind and cyclonic depression

Figure 90—Nimbus (rain cloud), altitu le 300 to 6,500 feet. Steady rain or snow usually falls

Figure 88—Alto-Cumulus; altitude 10,-000 to 23,000 feet. Indicate strong cross currents of air

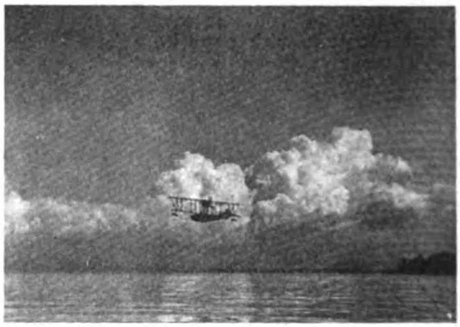


Figure 91—Cumulus (woolpack clouds), altitude 4,500 to 6,000 feet. Cause violent disturbances to the airplane

Figure 89—Strato-Cumulus; altitude 6,500 feet. Predict a change in weather

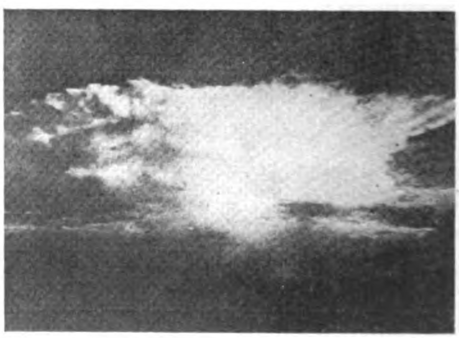


Figure 92—Cumulo-Nimbus (thunder cloud), altitude 4,000 to 26,000 feet. Dangerous to aviators because of strong currents and electric effects

CLOUDS AND THEIR SIGNIFICANCE

CLOUDS

Clouds are formed, (a) by condensation when an ascending mass of moist air encounters another moist mass of different temperature; (b) by cooling, when an ascending column of vapor, mixed with particles of dust, condenses. Types of clouds and their direction indicate the weather to the observing aviator. Clouds are either in the form of sheets or heaps, and may be so studied.

CLASSIFICATION OF CLOUDS

Cirrus—(Mare's Tails.) Light wisps of whitish cloud, of fibrous appearance with no shadows. These clouds are the highest in the international classification, commonly appearing at an altitude of 30,000 feet or more. They predict wind and a cyclonic depression. Illustrated in Figure 87.

Cirro-Stratus—A thin sheet of tangled web structure, whitish, and sometimes covering the sky completely, giving it a milky appearance. This cloud often creates sun and moon halos. Its average height is 29,500 feet. Forecasts bad weather.

Cirro-Cumulus—(Mackerel Sky.) Small globular masses or white flakes without shadows, or showing very light shadows, arranged in groups and often in lines. Average height between 10,000 and 23,000 feet. Denotes fine weather.

Alto-Stratus—A thick sheet of gray or bluish color, sometimes forming a compact mass of dark gray color and fibrous structure. Often causes brilliant caronae when near sun or moon. Average height 10,000 to 23,000 feet.

Alto-Cumulus—Large globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. Illustrated in Figure 88. This cloud formation is somewhat similar to the mackerel sky (cirro-cumulus): it has the same elevation, 10,000 to 23,000 feet. The cross lines indicate strong cross currents of air.

Strato-Cumulus—Large globular masses or rolls of dark clouds, frequently covering the whole sky, especially in winter. Altitude 6,500 feet. Illustrated in Figure 89. Predict a change in weather.

Nimbus—A thick layer of dark clouds without shape and with ragged edges from which steady rain or snow usually falls. Shown in Figure 90. Through the openings an upper layer of cirro-stratus or alto-stratus is almost invariably seen. Low elevation, 300 to 6,500 feet.

Cumulus—(Woolpack Clouds.) Thick clouds of which the upper surfaces are dome-shaped with protuberances; base horizontal. Illustrated in Figure 91. They indicate the aerial fountain and are low flying, 4,500 to 6,000 feet. Violent disturbances to the airplane will be experienced when passing through them, or passing above or below.

Cumulo-Nimbus—(Thunder Cloud.) Heavy masses of cloud rising in the form of mountains or turrets or anvils, generally surmounted by a sheet or screen of fibrous appearance (false cirrus) and having at its base a mass similar to nimbus (rain cloud). Illustrated in Figure 92. Apex 10,000 to 26,000 feet; base, 4,000 feet. Dangerous to aviators, because of strong currents and electric effects.

Stratus—A uniform layer of cloud which resembles fog but does not rest on the ground. It usually is stationary or drifting slowly at altitudes of 100 feet to 3,500 feet.

GENERAL OBSERVATION

Aviators may gain valuable knowledge of existing wind currents by observation of clouds. The general rule is that unbroken clouds indicate smooth, even air flow, broken formations the presence of air currents. The behavior of these currents may be anticipated by applying the above classification to the clouds in evidence.

British Official.

Although practically every personal narrative of aviators returned from France contains references of thrilling escapes from anti-aircraft guns, little is known of these weapons or their employment. Anti-aircraft guns are either of high power on fixed mounts, or light guns on movable mounts, such as is illustrated above in a photo from France. The heavy guns are usually set in concrete emplacements but the lighter ones are used with mobile forces and therefore designed to be moved as required. They are usually one or two-pounders, rapid fire and mounted on specially designed motor trucks. In a few instances heavy 6-pounders are employed; these are allotted to army corps and general headquarters, whereas the lighter pieces are generally assigned to brigades and divisions in the field. Explosive and special incendiary, combination time and percussion shells are used. The guns are generally arranged in triangular or square groups of three or four

Aviation News

The Aircraft Board has issued the following statement:—

Inter-Allied Conference on Standards

The arrival in England is announced of delegates from all the allied countries for conference on international standards, at which a standardization of manufacturing materials as related to the production of machinery, motors, aircraft, etc., will be considered.

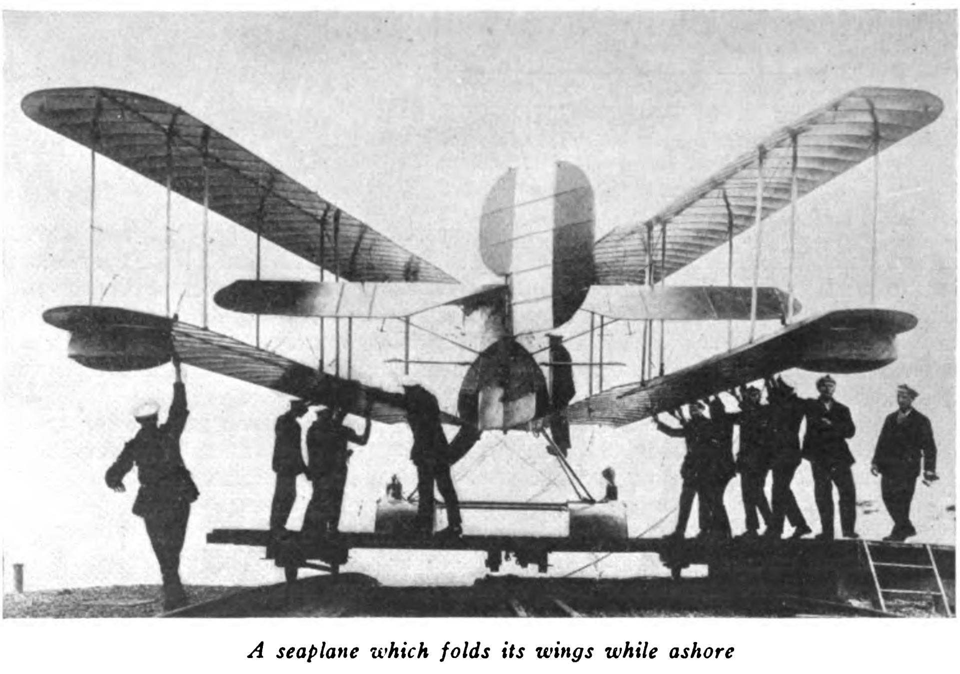
The American delegation, headed by F. G. Diffen for the Aircraft Board, includes members from all the prominent engineering societies of the country—the Society of Automotive Engineers, the American Society of Mechanical Engineers, the American Society of Testing Materials, etc. There are also members from the Aircraft Board, the Advisory Committee for Aeronautics, the Signal Corps, the Navy, and the original International Aircraft Standards Board, from which this conference is an outgrowth.

The purpose of this inter-allied meeting, which is the result of the efforts of Mr. Diffen, is to enable better industrial service to be given with less man-hour effort, through relieving plants from carrying in stock unstandard materials, for which there is small call, and concentrating on materials of known performance for the same work.

No attempt will be made by the conference to standardize airplane construction, but rather those materials and units only which are at present causing confusion in purchase and delivery and for which suitable standards can be established.

The following is the list of the American members:—F. G. Diffen (Chairman), Dr. W. F. Durand, Lieut. Commander Benjamin Briscoe, Lieut. W. F. Prentice, Coker Clarkson, E. H. Ehrman, Charles M. Manley, James Hartness, Albert L. Colby, F. G. Ericson, Capt. A. B. Tilt, F. R. Baxter.

Summer and winter flight uniforms only will be required of officers of the Naval Reserve Flying Corps, but they may provide themselves with Navy service uniform as prescribed for Naval Reserve officers, if they so desire, to be worn when not on duty specified below. Summer or winter flight uniforms will be worn by all officers on aviation duty attached to naval air stations and naval aviation detachments, ashore and may be worn on duty in connection with inspection or tests of aircraft and their material, and on such other occasions as may be prescribed by competent authority.



A seaplane which folds its wings while ashore

Progress of Wireless Telephony*

By Elmer E. Bucher
Director of Instruction, Marconi Institute

(*Continued from July* WIRELESS AGE)

Espenchied's Duplex Wireless Telephone System

AMONG the attempts that have been made to secure simultaneous transmission and reception in wireless telephony, the system evolved by Lloyd Espenschied is of interest. A problem of considerable magnitude is encountered in duplex transmitting and receiving systems because of the large amounts of power used for transmitting compared to that flowing in the receiving systems, the ratio being approximately one million to one. This inventor believes he has solved the problem through the use of specially devised balancing out circuits.

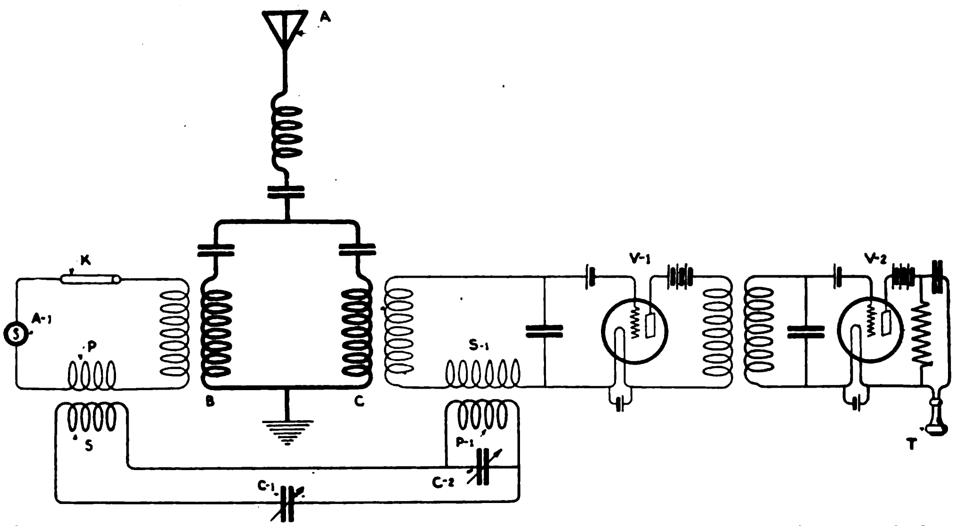


Figure 11—Espenschied's system for simultaneous transmission and reception in wireless telephony

The embodiments of Espenschied's system are shown in the diagram of figure 11, additional circuits being shown in figures 12, 13, and 14. In the systems shown in these diagrams the inventor secures duplex operation by employing different carrier frequencies for transmission and reception. Through the selectivity thus afforded and by the aid of additional balancing out circuits, either the same aerial or two different aerials may be employed for simultaneous transmission and reception.

In brief, the antenna system shown in figure 11, comprises two parallel branches *B* and *C* which gives the complete system two natural frequencies of oscillation. Branch *B* is coupled to a continuous wave generator *A*-1, and branch *C* is coupled to a valve amplifying system including the tubes *V*-1 and *V*-2. The speech signals are translated through the medium of the telephone *T* connected in the output circuit of the tube *V*-2.

Keeping in mind the enormous volume of energy flowing in the transmitting branch compared to that in the receiving branch, it is clear that some means of balancing out the effect of branch *B* upon branch *C* must be employed. This is

*Abstracted from "Vacumm Tubes in Wireless Communication."

accomplished by the balancing out circuit *S*, *C*-1, *C*-2, *P*-1. *S* is coupled to the radio frequency generator *A*-1 and to the input side of the three-electrode valve at *P*-1, *S*-1. By proper adjustment of the phase relation of the balancing out current and the current of similar frequency induced in the receiving system, complete annulment is secured in branch *C*. It must be remembered that the frequency of the balancing out circuit is that of the transmitter. Hence, only currents of this frequency are suppressed in the receiving system, leaving it free to receive waves at a frequency differing from that of the radio frequency alternator *A*-1. Careful adjustments of the couplings *P*, *S*, and *P*-1, *S*-1, are essential for successful operation.

The correct phase relation between the balancing currents is obtained by proper adjustment of capacity of the condensers *C*-1 and *C*-2.

The circuit shown in figure 12 is in all respects similar to figure 11 with the exception that the balancing out circuit includes a vacuum tube *V*-3 which ampli-

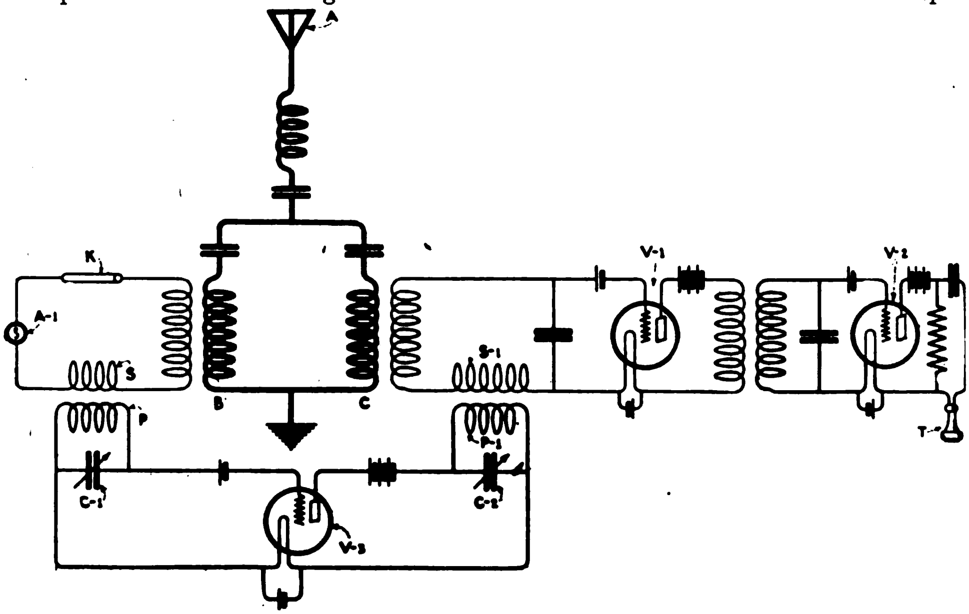


Figure 12—Modified system evolved by Espenschied for simultaneous transmission and reception of wireless telephonic signals. The interfering currents in the receiving system are balanced out by a special circuit P, C-1, P-1, C-2

fies the effect of generator *A*-1. Better balance of the opposing E.M.F.'s is thus secured.

It is thus seen that in a general way the circuits of figures 11 and 12 simulate the circuits of wire telephony, the apparatus always being in a position to transmit and receive.

A system involving the use of separate aerials for transmission and reception of speech signals disclosed by Espenschied is shown in figure 13. The aerial of the transmitter is indicated at *W*, and of the receiving station at *W*-1. The source of radio frequency for the carrier wave is shown at *A*-1, the output of which is amplified by means of the three-electrode vacuum tubes *V*-1 and *V*-2, the output current of the latter tube being fed to the aerial *W* at the coupling *P*, *S*.

The receiving system embraces the coupling transformer *P*-1, *S*-1, the incoming signal being amplified by the three-electrode tube *V*-3 and detected by the tube *V*-4. The output circuit of *V*-4 includes the receiving telephone *T*.

Through the transformer *M* and the microphone *T*-1, currents of vocal frequency are impressed upon the circuit *X* which also is inductively coupled at *M*-1 to the alternator *A*-1. The output of the alternator is modulated at vocal frequency by *T*-1. The circuit *X* is coupled to antenna *W* at *M*-3 through which high frequency current is withdrawn from the antenna circuit to balance out currents of similar frequency in the receiving system. Circuit *X* is coupled to

V-3 at *M*-2. This circuit thus serves to impress currents of speech frequency upon the alternator *A*-1 and to deliver a certain amount of radio frequency to the input circuit of the tube *V*-3 to balance out such energy as may be induced in the aerial *W*-1 by *W*. The correct phase relation of the opposing radio frequency currents is obtained by careful adjustment of condensers *C*-1 and *C*-2.

In respect to the reception of signals, it is seen that antenna *W*-1 is strongly responsive while antenna *W* is weakly responsive to the distant transmitter owing to the difference of frequency.

Summarizing the actions of the apparatus disclosed in figure 13, currents of radio frequency generated by the radio frequency alternator *A*-1 are amplified by a battery of vacuum valve tubes the output circuits of which are inductively coupled to the antenna. Circuit *X* serves to conduct radio frequency current

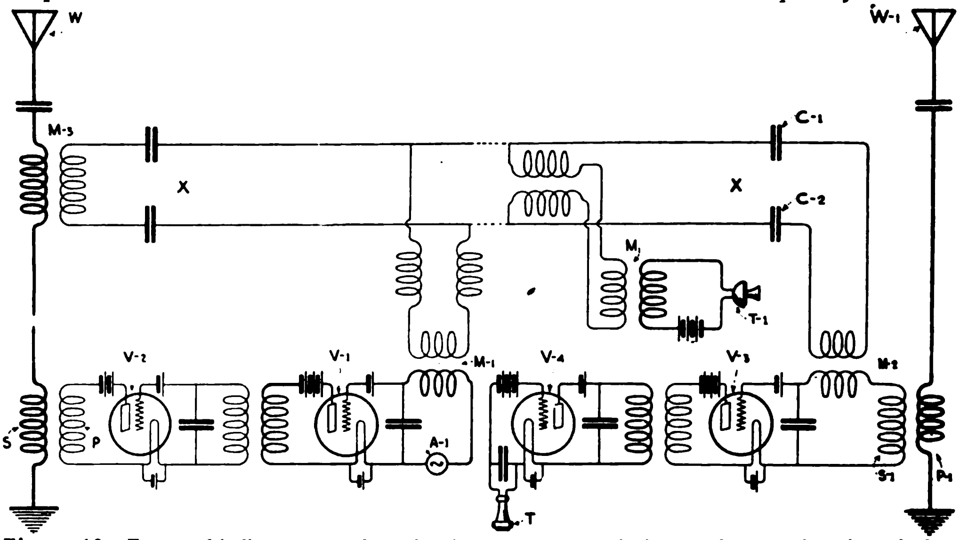


Figure 13—Espenschied's system for simultaneous transmission and reception in wireless telephony from two aerials

from the transmitter for balancing out the effects of the transmitter upon the receiving system. It acts also as a carrier of the vocal currents generated by the microphone *T*-1.

The system shown in figure 14 fundamentally is similar to that of figure 13. The output of the radio frequency alternator *A*-1 is amplified by the bulb *V*-1, the carrier wave being modulated at a radio frequency by the microphone *T*-1 through the coupling *M*. The output circuit of *V*-1 is coupled to the input circuit of the valve *V*-2, the output circuit of which is inductively coupled to the antenna through the transformer *P, S*. A balancing out circuit shunted across circuit *X* including the condenser *C*-1 and the coupling *M*-2 serves to impress a modulated radio frequency wave on the input circuit of the receiving system *V*-3, *V*-4, *T*, and thus currents of the transmitter frequency which may be induced in the antenna *W*-1 are balanced out leaving the receiving system free to respond to waves of a frequency differing from that employed in the antenna system *W*. Correct phase relation of the opposing currents is obtained by means of the condenses *C*-1.

Englund's Duplex Radio Telephone and Radio Telegraph System

We have remarked in the previous article how a vocal wave or current of speech frequency impressed upon a radio frequency or carrier wave sets up three complex waves of frequency $F + f$, F, and $F - f$, in which F is the frequency of the carrier wave and f the vocal wave impressed upon the carrier wave by the human voice through a microphone. Because the wave frequency F does

not contain the signal frequency, *f*, it represents a waste of power in the antenna system. Means were shown whereby the current of frequency *F* could be practically eliminated at the transmitter but be supplied at the receiver by a local generator.

Englund has recently disclosed a novel system which not only embodies the foregoing principle, but in which the frequency *F* is employed for telegraphic signaling. That is, the antenna is used for simultaneous radiation of telephonic and telegraphic messages.

An important feature of the system is the fact that telegraphic and telephonic signals may be dispatched simultaneously at the same wave length from one aerial and may be received upon one aerial at the receiving station. The transmitting circuits of this system are shown in figure 15 and the receiving cir-

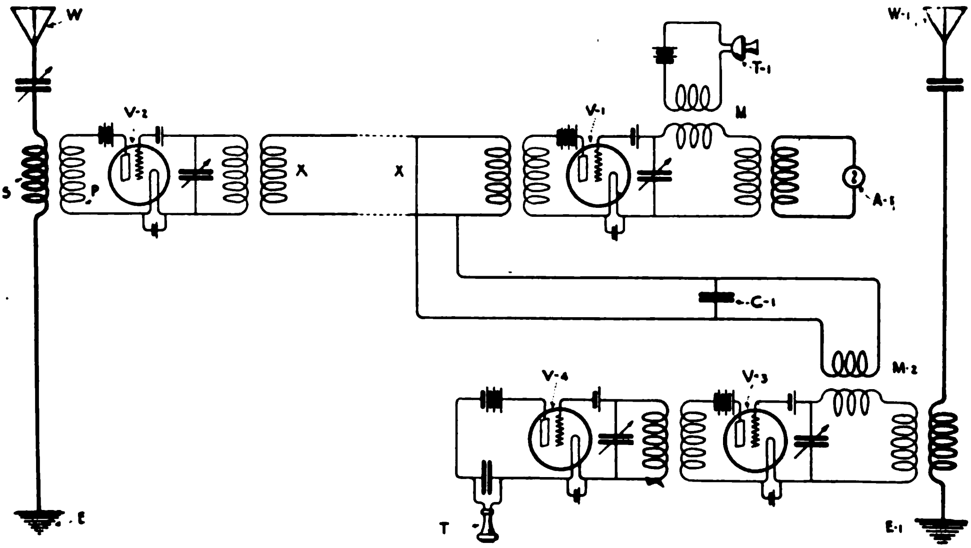


Figure 14—Espenschied's modified system for simultaneous telephonic transmission and reception from two wireless telegraph aerials

cuits in figure 16. Beginning at the left-hand side of the drawing of figure 15, a radio frequency alternator *A* is coupled to the input circuit *B* of a modulator bulb. Coupled to the same input circuit is a microphone circuit *C* including the microphone *T*, the battery *B*-3, and the transformer *M*-2.

The output circuit of the modulator bulb contains two branch circuits *B*-1 and *B*-2. The branch *B*-1 comprising the inductance and the condenser serves as a short circuit to current of the frequency of the generator *A*. The parallel circuits of branch *B*-2 are tuned to offer a practically infinite impedance to currents of the generator frequency and a low impedance to currents whose frequencies differ therefrom by a vocal frequency.

Through the transformer *M*, currents of vocal frequency are impressed upon the input circuit *F* of the amplifying bulbs *V*-1, the output circuit *G* being again coupled to a battery of power bulbs *V*-2. The output circuits of the latter are inductively coupled to the antenna at *M*-1. So far the circuit does not differ materially from that described in the July issue, and as already explained, the antenna only radiates when the transmitter *T* is actuated.

It is to be noted, however, that through the transformer *M*-2, and the telegraph key *K*-1, currents of the frequency of the generator can be impressed upon the input circuit *F* of the amplifying bulbs *V*-1. Therefore, during the moment that the key *K*-1 is closed, the antenna will radiate at the frequency of the alter-

nator *F*. The wave motion can be detected at the receiving station by a receiver tuned to that frequency. Thus, the current of the carrier wave is superposed upon the modulated current induced in the antenna circuit by the microphone. Telegraphic and telephonic signaling may then be carried on simultaneously.

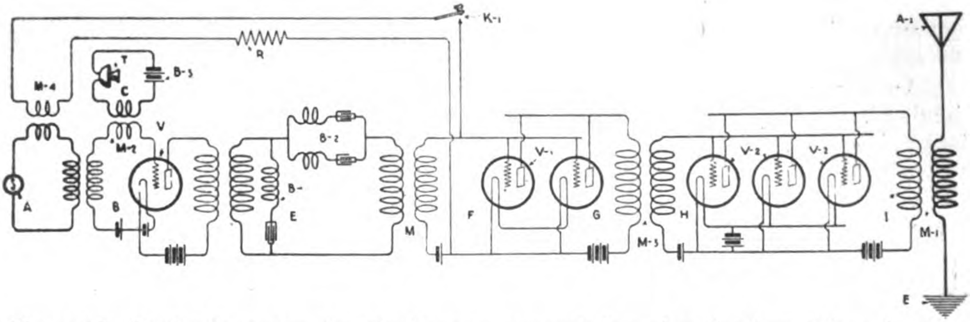


Figure 15—Englund's system for simultaneous transmission of radiotelegraphic and radio-telephonic signals

During the time that the key *K*-1 is closed, the speech distortion ordinarily caused by the presence of the frequency *F* in the antenna circuit in wireless telephony, is experienced, but at all other times the frequency of the carrier wave *F* is eliminated. However, it does not interfere seriously with the signals of speech or vocal frequency.

To avoid short-circuiting the amplifiers *V*-1, a resistance *R* is placed in series with the key circuit.

The circuits of the receiving system whereby telegraphic and telephonic signals may be recorded at the wave length simultaneously is shown in figure 16.

The carrier frequency *F* which has been eliminated at the transmitting sta-

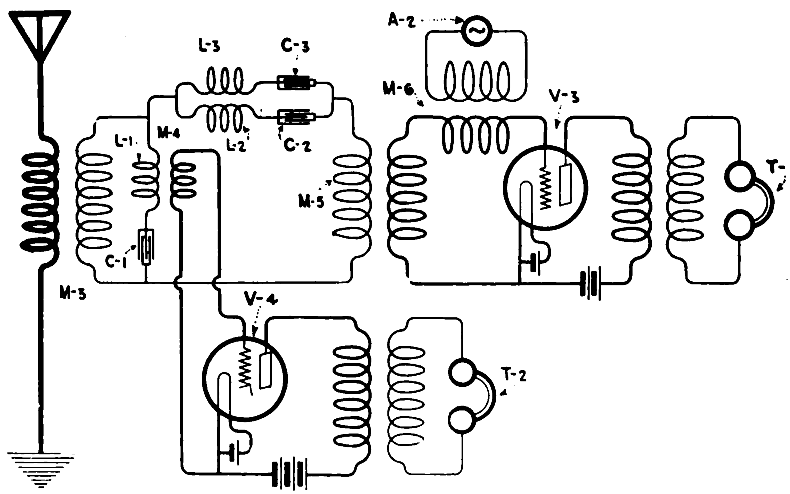


Figure 16—Receiving apparatus in Englund's duplex system. This system will receive telegraphic and telephonic signals simultaneously

tion for wireless telephony, is supplied by a local generator *A*-2 which is coupled to the input side of a three-electrode valve *V*-3, the output circuit of which is connected to a telephone receiver *T*.

The secondary of the receiving transformer *M*-3 is shunted by an inductance

L-1 and a condenser C-1, the circuit further containing the inductances L-2, L-3 and the condensers C-2 and C-3. This circuit will be found similar to B-1, B-2 of figure 15, performing similar functions. It is also to be noted that the input side of a vacuum tube V-4 is inductively coupled to L-1 by transformer M-4. It is in this circuit that the telegraphic signals are detected.

Keeping in mind the functions of the branch circuits B-1 and B-2, in the transmitter, the function of those of the receiver will be readily understood. Thus, oscillations of the carrier frequency will be shunted through L-1, C-1. Through the coupling M-4 they are impressed upon the input circuit of the tube V-4 and detected in the telephone T-2. Currents of the carrier frequency cannot appear in the transformer M-5 which serves to couple the antenna system to the input circuit of the valve V-3, but currents of vocal frequency are readily transformed through M-5 because of its tuning and thus are detected in the telephone T-1.

In summary, the telegraph signals are detected in telephone T-2 and tele-

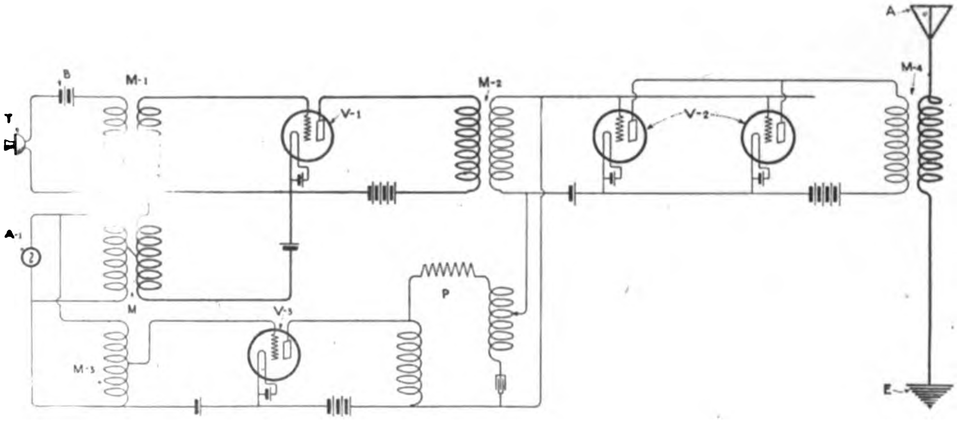
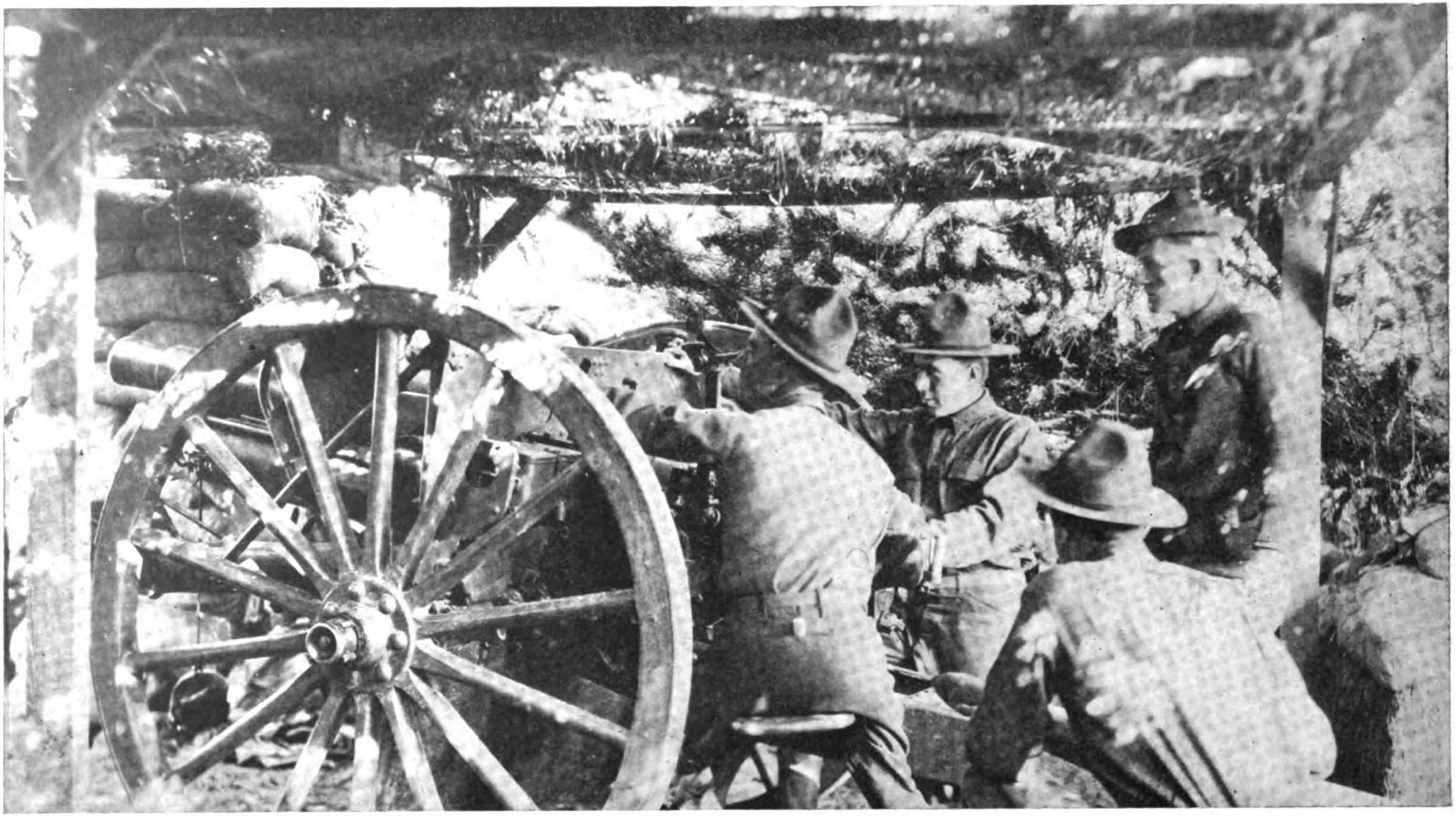


***Figure** 17—System proposed by Englund for the elimination of the carrier frequency; with the apparatus connected in this way the antenna radiates only when modulated currents of vocal frequency are generated*

phonic signals in T-1. The alternator A-2 supplies the carrier frequency F which has been eliminated in the telephone transmitter circuits.

Englund has disclosed another system for elimination of the carrier frequency at the transmitting station in wireless telephony, it being a modification of the circuits disclosed in the July article. The complete circuits are shown in figure 17. As usual, the radio frequency carrier wave is generated by the source A-1, which is inductively coupled to the input side of the three-electrode tube V-1, the same circuit being coupled at M-1 to the transmitter circuit including the microphone T, and the battery B. The output circuit of V-1 is inductively coupled through M-2 to the input circuit of the power bulbs V-2. The output circuit of the latter is, in turn, inductively coupled to the antenna circuit as usual at M-4.

Up to this point, if the transmitter T be spoken into, the antenna would radiate at three frequencies, that is the *carrier frequency* would not be eliminated. A special balancing-out circuit, however, is provided, which is connected to the alternator A-1 in the following way: The input side of a vacuum tube V-3 is coupled to the alternator through the auto-transformer M-3. The output circuit of V-3 is connected to a phase-regulating device P, consisting of inductances, capacity and resistance, as shown. This circuit is in turn tapped across the secondary winding of the transformer M-2 so that currents of the carrier frequency F which may be induced in the circuits of M-2 are balanced out by opposite phase regulation. The antenna then radiates only during the production of the wave of vocal frequency.



(C) Press Ill. Svce.

The famous 3-inch field artillery gun of the U. S. Army is seen here made ready for action in position exactly duplicating the screened and protected emplacement which these Americans will find abroad

A Digest of Electrical Progress

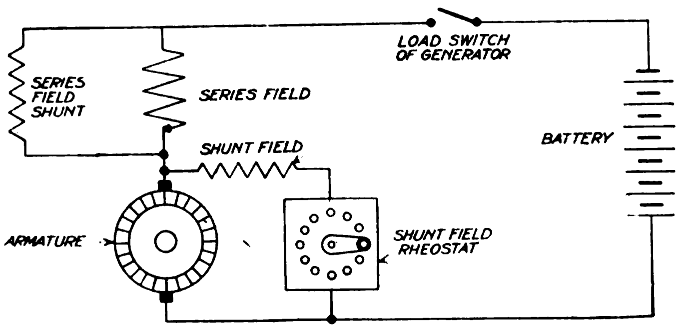
Enormous Growth in Sale of Tungsten Lamps—Protection of Battery Charging Circuits—New Research Laboratory in Japan—Electric Welding in the Building of Ships—New Swedish Radio Station—An Early Phonograph Concert—Recognition to Dr. A. E. Kennelly—Belated Recognition of Oliver Heaviside—Carty Receives the Edison Medal.

Enormous Growth in Sale of Tungsten Lamps

IT is reported that the total sales of tungsten filament lamps in the United States excluding miniature lamps, for the year 1917, totaled 165,000,000, an increase over the previous year of 14 per cent. It is also declared that more than 75,000,000 miniature lamps were sold during this period. The majority of these are used for flashlights and automobiles, but a considerable number are also employed for candelabra and decorative lighting. The total sales of carbon filament and tungsten filament lamps totaled about 12 per cent out of 100 per cent.

Protection of Battery Charging Circuits

THE importance of including a reverse current circuit breaker in the circuit of a charging generator is shown by the incident described by E. C. Parham in a recent issue of the Electrical World. He remarks:



Connections of motor-generator circuit

A motor-generator set after being connected to some batteries all night appeared to be unable to charge the batteries. The set was found to be running at a reduced speed with circuit breaker open. The accompanying diagram indicates the connections.

The set was shut down by pulling the knife switch and the generator was carefully inspected. The series field coil interconnections were of the clamp type and the clamp of the two bottom coils had worked off, thereby opening the series winding and making it necessary for the series-field shunt to carry the total current. Had there been no series-field shunt the loosening of the clamp would have opened the circuit between the generator and the battery and there could have been no motoring action.

As it was, however, the cutting out of the series winding lowered the voltage of the generator to a value that was below that of the battery and the

shunt held intact the circuit that was necessary for the motoring. Up to the time of the opening of the motor breaker the driving motor and the battery had been operating the set in the same direction.

New Research Laboratory in Japan

A NEW physics and chemistry research laboratory has been recently organized in Japan. It is a semi-governmental institution, part of the foundation being furnished by the Government and the rest by private subscribers.

Several young scientists have been nominated as members of the staff, and some of them are at present in the United States studying laboratory methods. The noted physicist, Dr. Nagaoka, is the head of the physics department, and Dr. Ikeda is the head of the chemistry department. The object of this institution is to conduct original investigations in physics and chemistry and to apply the results for the promotion of industry. To accomplish these objects and to make the institution closely related to outsiders, the articles of incorporation contain the following provisions: (1) Private parties may apply for research to be done on specific subjects; (2) Outsiders may obtain permission to utilize the equipment of the institution; (3) Outside investigators may obtain assistance for completing their investigations or inventions; (4) The institution will publish the results of researches conducted in it; (5) The institution will provide public lectures for the dissemination of the results of its research; (6) The institution may confer honorary degrees upon those who have accomplished original research of merit; (7) The institution will conduct correspondence with other similar institutions of the world and co-operate with them; (8) The institute will undertake training of research men.

Electric Welding in the Building of Ships

PROFESSOR Comfort A. Adams, chairman of the standards committee of the American Institute of Electrical Engineers, has appointed a special committee to investigate the possibilities of electric welding in ship building. This committee includes representatives from the manufacturers of welding machinery, the classification societies (Lloyd's and the American Bureau of Shipbuilding), the Bureau of Standards, the Navy Department and shipbuilders. As a result of their investigations, the members of the committee became convinced that time and material could be saved by the introduction of electric welding methods. The committee was re-organized and assigned a definite work by the Emergency Fleet Corporation. An office has been established in room 716, Engineering Societies Building, New York City.

The Emergency Fleet Corporation has authorized the construction of a 50-ft. (15.2-m.) section of a 9,600-ton standard ship at the yards of the Federal Shipbuilding Company, Newark, for the demonstration, development, and application of electric welding to an actual ship structure. The construction of this 50-ft. section will be under the direction of Arthur J. Mason, of the Fleet Corporation, who has been active in advancing the use of electric welding for ship building. The particular ship section is to be sealed up at the ends, filled with water, and tested by hydrostatic pressure. Both spark and arc welding are to be employed. The foundation for this structure is already complete, and the work will be pushed as rapidly as possible.

Large stationary and portable spot welders are being designed for this work, and various arc-welding systems are being studied. An installation will be made in the Hog Island yard at Philadelphia.

The committee is responsible to Daniel H. Cox, manager of steel ship construction of the Emergency Fleet Corporation, who is lending every possible aid to its work.

All available information as to apparatus, tests and applications is being collected. This information, together with that already in hand, will be classified and sent out to all steel shipbuilders and to others interested.

New Swedish Radio Station

THERE has been completed at Karlsborg, Sweden, a wireless station for which is claimed ability to send messages over a distance of 3,150 miles. The masts for the support of the antenna are 684 feet in height, but weigh only 25 tons each. They are insulated at four different places from base to top and are erected with the bases embedded in black granite blocks, impregnated with paraffin. The antenna is 1,476 feet in length, consisting of sixty phosphor-bronze wires hung from steel tubes. The capacity of the station is increased by covering the territory between the masts with a phosphor-bronze wire netting.

An Early Phonograph Concert

H. P. GALLIGHER tells, in the Telegraph and Telephone Age, that he first heard phonograph signals in the year 1887 while he was working as night operator at Corry, Pa. It was in the autumn, and he was busy in the telegraph office and a train pulled into the station; a stranger, a young man of perhaps twenty-six or twenty-seven years of age, of slight build, and quiet, studious manner, came into the office. He stated that he was an operator, explaining that he came from Buffalo to see what arrangements could be made for connections through the board on a certain evening on which he was to give a concert in Buffalo, his audience being in Cleveland. The writer remarks:

> "The big, button switchboard, three feet square, was at that time more or less a mystery to me. He seemed to be familiar with its operation, however, and explained what it was he wanted done on the evening of the concert. I did not care to take the responsibility, as I might be too busy, and told him to watch out for 'MS' calls and I would go after Will Fox, the day man. Mr. Fox agreed to be on hand the night of the concert and look out for the wires.
>
> "Before leaving, Thomas A. Edison, for he was the stranger, told me to hold my ear down to the magnet of the relay on the night of the concert and I could hear the music. I did so. I could hear the cornet solo very distinctly, but the singing and the orchestra were only a humming sound."

It is interesting to note that the phonograph signals were recorded by the vibrations of an armature relay and not by the familiar telephone receiver. Its vibration was, of course, too crude to record the variations of orchestral music.

Recognition to Dr. A. E. Kennelly

IN addition to the honors which Dr. A. E. Kennelly has received here and abroad for his research work along various electrical lines, he has recently been awarded the Howard N. Potts gold medal by the Franklin Institute, for his invention of the hot wire ammeter and his application of this device to the measurement of convection from small heated wires. Dr. Kennelly at present is acting head of the electrical engineering department of the Massachusetts Institute of Technology. He is well known to radio engineers for his contributions to the Proceedings of the Institute.

Belated Recognition of Oliver Heaviside

THE Board of Directors of the American Institute of Electrical Engineers has elected Oliver Heaviside an honorary member. The recipients of this honor are few in number, comprising Andre Blondel, S.Z. de Ferranti, C. E. L. Brown, and Guglielmo Marconi.

Heaviside is universally recognized as a powerful electrical physicist whose brilliant work on electromagnetic theory laid the foundation upon which the great superstructure of long distance telephony has been reared.

It should be remembered that as early as 1887 he demonstrated theoretically and urged the use of inductance in telephone circuits; but so little was the value of his suggestion recognized that Sir William Preece suggested for a trans-Atlantic telephone cable a cable of special construction in which the electrostatic capacity was increased.

Regardless of the ignorance and prejudice with which he was required to cope, in developing his theories, he continued in his experimental work, and in a series of articles published in the London Electrician in 1893, he suggested having "large distributed inductance together with inductance in isolated lumps. This means the insertion of inductance coils at intervals in the main circuit."

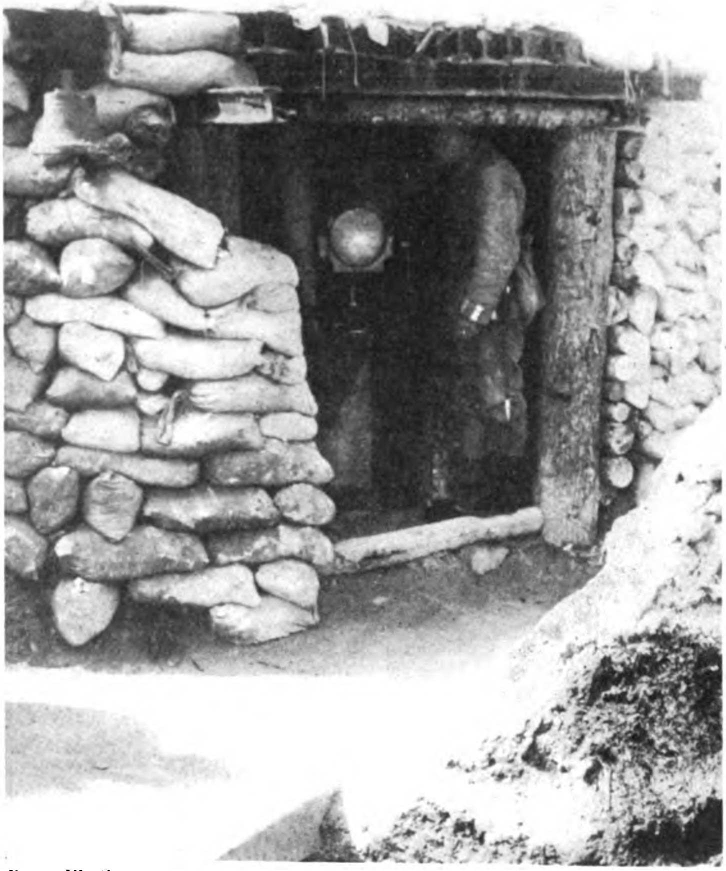
Dr. J. J. Carty, of the American Telegraph and Telephone Company, demonstrated the truth of Heaviside's scientific reasoning fully twenty years after the introduction of Heaviside's theories.

Commenting on the latter's accomplishments the Electrical World says editorially:

> Not alone, however great this work has been, can it be viewed as Heaviside's life work. Besides numerous contributions to the science of mathematics of utmost and revolutionary importance, there are the Heaviside units, called the "rational" units; there is the "rational" current element used throughout his work by Sir Joseph Thomson; there are the fundamental equations of the motion of an electrically charged body, with all the ramifications of mathematical and scientific work, which has culminated in the theory of the electron, and inseparably connected with Heaviside's name is the "distortionless circuit" and its beautiful theory. A busy age may plead preoccupation in extension of its failure to give earlier official recognition. So many are the subjects touched upon in Heaviside's writings, so absorbing and stimulative are these contributions to electrical science, that they have been an inexhaustible source from which lesser men have drawn material for interesting and instructive papers. The theory of the distortionless circuit, the building up of the steady state from a conception of direct and reflected waves, the use of operators—all these are but a few of the contributions made more than a quarter of a century ago, and they are cited at random from the wealth of Heaviside's papers. May this recognition of one of the greatest mathematical physicists the world has ever known convey to Great Britain and her men of science another message from America that in realization of each other's strength must lie the basis of their enduring greatness and invincibility.

Carty Receives the Edison Medal

THE Edison Medal for "meritorious achievement in electrical science or electrical engineering or the electrical arts" was established upon the initiation of a group of friends and associates of Thomas A. Edison, for the purpose of recounting and celebrating the achievements of a quarter of a century in the art of electric lighting. It was decided that the most effective means of accomplishing this object would be to establish a gold medal which during the centuries to come should serve as an honorable incentive to scientists, engineers, and artisans who achieve a high standard of accomplishment. This medal was presented to Colonel Carty at the annual meeting of the Institute to be held in the auditorium of the Engineering Societies Building. The meeting was presided over by President E. W. Rice, Jr. An address was given by Dr. A. E. Kennelly. Another address given by Michael I. Pupin gave the history of Colonel Carty's work in regard to telephone engineering. The medal was presented to Colonel Carty by President E. W. Rice, Jr.



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The construction of a gun emplacement for light pieces is revealed in detail in this trench view of a well defended position. Atop the sand bags to the left is the bell which is rung to warn of an enemy advance. These bells were formerly used by the allies to sound the "gas alert," but have since been replaced by Strombos horns, which can be distinctly heard above the roar and rattle of gun fire

Navigation News

The Shipping Board authorizes the following:

How a Ship's Tonnage Is Figured Four Ways

To many persons who are not experienced shipbuilders the various uses of the term "tonnage" in relation to the size of a ship may be confusing. The following article from the "Pusey & Jones Shipbuilder" explains the terms well and makes a clean distinction between the various ways in which they are used:

There are four kinds of tonnage in use in shipping circles. They are gross tonnage, net registered tonnage, dead-weight carrying capacity, and displacement.

Dead-weight tonnage is what the vessel actually can carry in tons of heavy cargo, plus stores and bunker coal.

Gross tonnage is based on the cubic contents of the hull, with certain arbitrary spaces deducted, and has little bearing on the cargo-carrying capacity of the vessel.

Net registered tonnage is gross tonnage, with certain allowances for crew space and machinery space deducted, and has little bearing on the dead-weight carrying capacity of the vessel.

Displacement is the total weight of the vessel when full of cargo—that is, the weight of her hull plus her dead-weight tonnage.

In round numbers a ship of 9,000 tons dead-weight would stand about as follows:

Dead-weight carrying capacity......	9,000
Gross tonnage	5,000
Net registered	3,000
Displacement	12,000

Director General Charles M. Schwab has announced the creation of a requirement section for the Emergency Fleet Corporation with Mr. George M. Brill as its head.

New Section is Created For Fleet Corporation

Mr. Schwab in creating this new section said:

"It will be the purpose of this section to keep in touch with the shipyards and learn from them in a general way the amount of materials, supplies, and equipment required for extensions, so that a proper schedule may be placed before the War Industries Board for survey, and, if necessary, for allocation. I think you will appreciate that during this time, when the demand for many materials is so far in excess of the supply, it is most essential that a clearing house be provided so that the needs of different Government agencies may not conflict.

The State Department has transmitted to the Chinese Government the following message from Edward N. Hurley, chairman of the United States Shipping Board:

China to Build Merchant Ships

"The United States Shipping Board has completed negotiations for the construction of a number of merchant vessels at the Chinese Government's shipyard at Shanghai. This happy arrangement enables Chinese industry to become still more effective in support of our splendid armies who are now advancing toward their assured victory. By making ships, China will be directly making war upon the common enemy."

Following the conclusion of an arrangement with the Kiangnan Dock & Engine Co. of Shanghai, whereby that company is to build 120,000 tons of steel steamships for the United States Shipping Board, it is announced that contracts for 30 additional steel cargo steamships have been awarded to Japanese shipyards.

Contracts for 30 Steel Cargo Ships Awarded to Japanese Yards

Total contracts now let to Japanese shipbuilders provide for 380,000 tons of shipping, including 50 cargo carriers. These will cost approximately $78,000,000, of which about $20,000,000 has been expended. The estimate of the Shipping Board, which was submitted to the Appropriations Committee of the House, asked for an additional $55,000,000 for this purpose. The Shipping Board had also permitted Japan to obtain 100,000 tons of steel plates, and will now provide 35,000 tons for this new construction.

Finding Your Way Across the Sea

Capt. Uttmark's work has taxed his health to such an extent that he has been compelled to temporarily suspend his writing. His department will be resumed in October.

The Monthly Service Bulletin of the

NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

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Chief of Relay Communications

Headquarters, 25 Elm St., New York

WE are reliably informed by the Federal Board for Vocational Education, through their Vocational Summary, that a great demand still exists for the services of expert radio telegraphers. Members of the association approaching the draft age should devote their spare time to thorough study of the wireless art in order that they may serve their country most effectively when called.

A considerable amount of self education can be effected through the wireless literature now available. There are also a number of first class schools throughout the United States in which for a nominal fee the applicant can receive advanced instruction. The education so obtained is bound to lead to rapid promotion because obviously the more one knows of a certain art, the more valuable his services become to the government.

The association headquarters stands ready to assist each one to complete their education in every possible way. Advice will be given on all problems which may arise in connection with the work. Members are urged to use these columns freely.

The interchange of ideas between French and American Engineers at the battle front is resulting in widespread progress in the practical applications of wireless telegraphy. It is reported that French engineers were amazed at the completeness of the wireless telegraph equipment furnished by the United States to its fighting men for war purposes. Many other electrical devices of great utility have been supplied to our fighting forces. Fritz must be careful these days, for his conversations in the trenches 1000 ft. distant are readily picked up.

We regret that we cannot publish more details as to how this detective work is carried on.

Have you heard of any new discovery in radio since the war? If so, keep it under your hat for there may be enemy ears nearby. Radio students should not talk too freely these days. Notebooks used in the classroom should not be allowed to lie around promiscuously. Any information which may be of aid to the enemy should be zealously guarded. It is a foregone conclusion that the members of the N. A. W. A. are living up to this necessity.

J. K. D., of Kansas City, Mo., writes as follows: "As a former member of the association I write to ask you what should be done in a predicament

such as the following: After careful consideration of fundamental wireless principles, I have developed an idea, which I think would be of ultimate value to the art, but not being permitted to conduct wireless experiments, I have no opportunity to test my invention.

"I write to ask if you believe it possible that the government will grant me authority to conduct experiments to determine the usefulness of this device?"

We doubt very much if the government will grant this permission unless the experiments are conducted under the supervision of a government officer.

If our correspondent believes his apparatus of sufficient value to be of aid to the government, he can arrange either with a wireless manufacturing company, or with the government officials to conduct experiments under their supervision.

Kenneth Sutherland, age 19 years, a Topeka, Kansas, boy, has given his life on the fields of France for his country and the principles of democracy.

Sutherland, whose call letters were 9 D Q, is officially reported killed in action on July 17.

Many amateur wireless friends will regret the death of Kenneth Sutherland, the young Topeka wireless operator, who at the age of 18 years enlisted in Company A, Signal Corps, and began his trip to give his life for America. He was born in Topeka and lived there all of his life. He graduated from the Topeka high school just before his departure with the company to Camp Doniphan. He sailed on May 19 for France.

Young Sutherland had as his hobby the operation of wireless outfits. He was known as one of the foremost radio men in Kansas and was president of the Kaw Valley Radio Association.

"He was wild to go when war was declared," his father stated, "and we did not have the heart to break the boy's spirit." Today Kenneth is remembered as one of America's sacrifices for liberty.

The word of young Sutherland's death was the first information received that his radio company had gone into active service. Numerous letters have been received by Topeka friends and relatives of the men, telling of the training in France, but the latest letters received said nothing about active service.

HEARD IN THE CORRIDOR AT MARCONI INSTITUTE

(Reported Verbatim)

"Oh boy! you remember the night that Larney tried to reach Denver from Boston?

"Yeh? Did he do it?"

"Sure, after calling for half an hour, Denver came right back."

"Some work!"

"You said it. When Larney signed off a faint murmur slipped through the ether."

"Yeh? Wha'd'd he say?"

"He said, 'Hey Larney!—mind taking your bloomin' aerial off mine? It's been down two days.'"

"Gee crickets! Any casualties?"

"Few. One burned-up bulb, one pair of 'phones, and a scared-stiff bean-eater."

"Must 'a been an apartment house."

"Sure! Six aerials on one roof."

"Make good clotheslines!"

"Sure, six dead niggers up to April, 1917."

Major F. Reichenbach, signal corps, U. S. A., has sent out a call for cable operators, radio operators, telephone men who have had actual experience in construction, engineering, operation and maintenance of commercial companies, telephone and telegraph wire chiefs, cable splicers, machinists and gasoline engine men.

The age limits are from 18 to 55 years. Applicants must be American citizens or must have made legal declaration of intention.

Experimenters' World

FIRST PRIZE, TEN DOLLARS

A Simple Regenerative Receiving Set

IF amateur experimenters are permitted to use their apparatus when this war is over, there will be a greater demand than ever for a first grade equipment. One type of apparatus that will be particularly required is a receiving set which responds to both damped and undamped oscillations. Many amateurs prefer a receiving set of great simplicity—one which does not require complicated multipoint switches, and a number of soldered connections. I have therefore, shown the construction in the second diagram of a receiving panel that will be suitable for their requirements.

The cabinet may be of any wood properly finished. It should have over all dimensions of approximately 15″ x 10″ x 7″.

As will be noted from the diagram, the set proper consists of 3 variometers, one condenser, and a three-electrode vacuum tube.

The antenna variometer consists of two cardboard tubes 3½″ and 3″ in diameter, respectively. The 3½″ tube is wound with 45 turns of No. 32 single

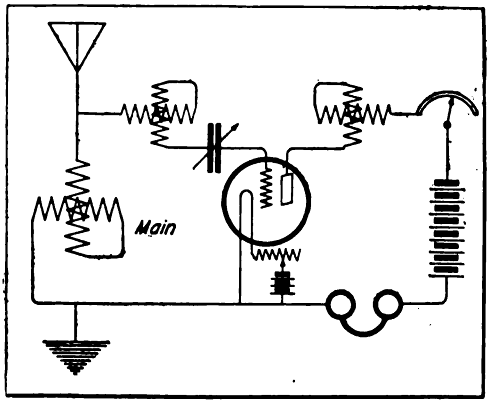


Figure 1—First prize article

silk wire, and the other tube with 50 turns of No. 32 single silk wire.

The grid and plate variometers are identical. They have the same dimensions as the antenna variometer except that they are wound with 30 turns on the outside tube, and 35 turns on the inside tube.

The variable condenser has a capacity of .0005 mfd.

Referring to the drawing of the panel, the lower left hand knob con-

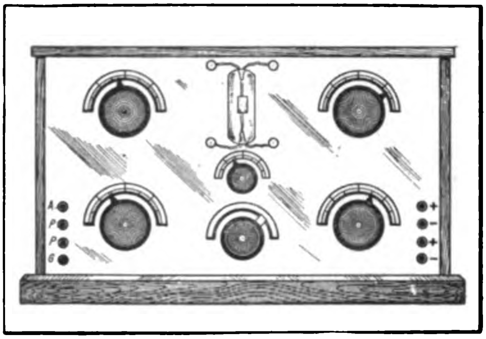


Figure 2—First prize article

trols the antenna variometer, the upper left hand knob the grid variometer, and the upper and lower right hand knob controls the condenser and the variometer in the plate circuit, respectively.

The control knob directly under the vacuum tube is attached to the filament rheostat within the box. The remainder of the diagram, and construction of the panel is self explanatory.

It is to be noted that by this method of connection, the plate circuit is tuned to the frequency of the incoming oscillations, and that the required regenerative coupling is furnished by the tube itself. If, however, greater amplifications are required, inductive coupling can be provided between the grid plate circuit by placing the grid variometer and the plate variometer in proximity.

The advantage of this apparatus lies in the fact that there are no variable contacts or multipoint switches, the necessary tuning being done simply by turning the variometer.

In some cases it may be of advantage to shunt the plate battery and the head telephone by a variable condenser.

JOSEPH LIGMOND,
New York City.

Specialists in camouflage for the U. S. Army developing new methods of battery concealment on a model

SECOND PRIZE, FIVE DOLLARS

The Design of a 500-Cycle Transformer

IT has been shown that for maximum efficiency the iron losses in transformers should be approximately equal to the copper losses.

Assume for example that the design of a ¾ K. W. transformer is under consideration; with a loss of 6% and efficiency of 94%, the total loss will be 45 watts; one-half of this or 22½ watts will then be the iron loss.

The watt loss per lb. for good silicon steel .014″ thick at 500 cycles is approximately 1.2 watts. Dividing this into 22½ gives 19 lb. as the weight of iron. Dividing 19 by .276 gives 68 cu. in. for the total amount of metal. For economy of copper, and to facilitate the cutting of the metal, the transformer should be square in form and in cross section.

Assume 1.7″ for the side and 2.89″ for the cross section; their product divided into 68 gives 23.5″ as the mean length of the path. Dividing the result by 4 gives approximately 5.87″ or 7.25″ outside and 4″ inside length.

With steel of the above dimensions we shall require about 59 pieces to the inch, or totally 400 pieces 1.7″ wide by 5.9″ long.

We may assume a primary voltage of 100 volts, current of 7.5 amperes; also a secondary voltage of 10,000 volts current of .075 ampere and the ratio of transformation to be 100. The formula,

$$V=\frac{4.44\times a\times b\times n\times t}{10^8}$$

can be changed to

$$t=\frac{v\times 10^8}{4.44\times a\times b\times n}$$

where,

v=voltage,
a=cross sectional area,
b=density in lines of force per sq. in.,
t=number turns of wire.

Allowing 15000 lines per sq. in. and solving for

$$t=\frac{100\times 100\ 000\ 000}{4.44\times 2.9\times 15{,}000\times 500}=112$$ turns for primary, and since the ratio of transformation is 100 there will be 11,200 turns in the secondary.

For radio work 1000 circular mils should be allowed for current of 1 ampere. This calls for a conductor of 5700 cir. mils. for the primary coil and 75 cir. mils for the secondary coil. Using the next larger size wire we employ No. 11 (8234 cir. mils) for the primary, and No. 31 (75 cir. mils) for the secondary.

If we use .25″ Empire cloth to insulate the primary between the ends of the coil, and allow for the yoke between the coil and the core, the winding length will be 3.5″. In this space we can wind 3 layers of 35 turns each. An additional 7 turns can be placed in the middle of the coil to make up the 112 turns.

The secondary should be divided into 10 sections of 1000 volts, and 1120 turns each. Allowing the same thickness of insulation for the secondary as the primary, and 1/32″ between coils, we can wind 10 coils consisting of 59 layers of 19 turns per layer, for the secondary.

The overall efficiency may be determined as follows: The mean length of a primary turn is 8.5″ and for 112 turns this equals 80 ft. At 1.3 ohms resistance per thousand ft.

$R=.1$ ohm

$I^2 R=7.5^2\times .1=5.6$ watts for the copper losses in the primary coil.

The mean length of the secondary turn is 10.6″, total 9900 ft. At 131 ohms per 1000 ft.

$R=1257$ ohms

I^2 R loss$=.075^2\times 1297=7.2$ watts for the secondary losses. The total copper loss therefore equals 13 watts, the iron loss=22.5 watts, and the efficiency=

$$\frac{750}{750+13+22.5}=95\%$$

The primary and secondary inductances may be determined by a modification of the formula given by Messrs. Franklin and Williamson in their work on Alternating Currents as follows:

$$L=\frac{4\times n^2\times \lambda}{1}\left(\frac{X}{3}+\frac{Y}{3}+g\right)10^{-9}$$

Where L=Inductance in Henries,
n=number turns
1=2 times the height of the transformer window
λ=thickness of core,
X=thickness of pri. coil,
Y=thickness of sec. coil,
g=distance between coils,

The above dimensions are in centimeters.

For this example

$$\frac{4\times 3.14\times 12{,}544\times 4.3}{20.3}\left(3.3+7+6.9\right)$$

10^{-9}=.00069 Hy. pri. reactance.

This may or may not be the correct value required. If not, the dimensions of the transformer will have to be changed.

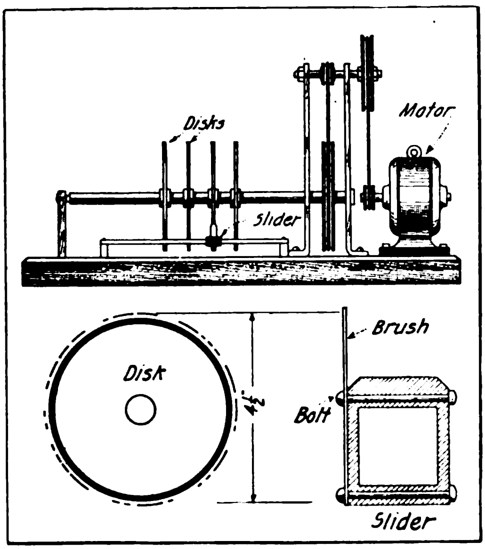
J. J. Holahan,
Virginia.

THIRD PRIZE, THREE DOLLARS

Apparatus for Self Instruction in the Continental Telegraph Code

ALTHOUGH the Government has caused all amateur stations to be closed for the period of the war, they should not neglect to keep up their code practice. The ordinary buzzer gives only sending practice, but the device described herewith will give receiving practice, which as is well known, is the harder of the two to master.

The apparatus which I am about to describe can be cheaply constructed. The necessary parts can usually be found around the amateur's laboratory.



Figures 1 and 2—Third prize article

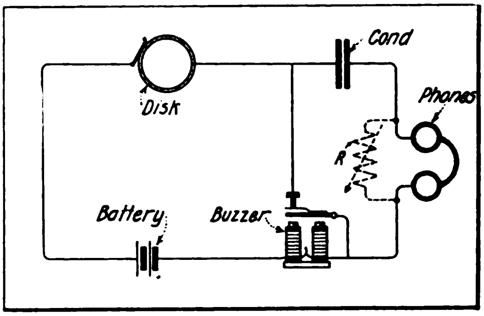


Figure 3—Third prize article

The assembled instrument is shown in figure 1, and the details of the cardboard discs are shown in figure 2. Figure 3 is a wiring diagram of the apparatus.

The disc shown in figure 2 is 4½" in diameter. Pieces are cut out of the circumference to form the dots and dashes of the International Code. The discs are then thoroughly shellacked and baked in an oven.

Strips of tin foil which are shown by the dotted lines in figure 2 are pasted on the cardboard disc, and connected to a copper washer in the middle. Care should be taken to cut the tinfoil exactly the same size as the dot or dash on which it is pasted, for otherwise, some dots and dashes will be longer than others. After this is done, the discs are clamped by means of bolts on a threaded shaft which is revolved by an electric motor as shown in figure 1.

The brush shown in figure 2 is made out of sheet brass and screwed on to an ordinary tuning coil slider. The brush may be pushed up and down the slider rod in contact with whatever disc the student desires to use. In this way he may receive practice from a large number of messages.

This device will work well as a flasher of lights on a 110-volt circuit, but a telegraphic relay must be employed because the high voltage would fuse the tinfoil.

J. Wiseman, Jr., *California.*

Construction and Operation of the Field Telephone and Buzzer

THE importance of the work of the Signal Corps in the present war cannot be overestimated, for it is this branch of the service that makes it possible for officers commanding units to keep in touch with the trenches and headquarters of the field troops.

Among the various means of communication are the telephone, buzzer, telegraph, wireless, semaphore, and numerous other methods. The telephone and buzzer are mostly used on the battlefield. The Signal Corps of the U. S. Army have a set which combines both instruments.

Taking this into consideration the writer has made a careful study of the various instruments now on the market, and has designed a set along approved lines, suitable for junior military organizations. He also originated the circuit, his sole object being to make it as simple as possible and to give young men a standard set from which they could use parts for other branches of signaling.

This outfit will not cover 27 miles as the army set, but it will work up to 4000 feet as a telephone set and a great deal further with the buzzer.

It has always been my desire to pick up a book or magazine and find a description of just what was needed for field signaling and no more, but so far I have seen nothing suitable for such service. Now that I am familiar with electricity in its various branches, I decided to give young men an opportunity to benefit by my experience.

The complete circuit is shown in figure 1. It permits the use of either the telephone or the buzzer. Several advantages result from this combination. For instance, if interference makes it difficult to hear the party's voice, the buzzer may be used instead.

We will first consider the buzzer connections. In the drawing they are shown ready for use. Starting at the positive pole of the battery, a wire leads to the lower contact of the key, also to contact No. 5. Contact No. 5 is not connected. Depress the key and the current flows into the buzzer through contact No. 12, out through No. 10 and back to the negative pole of the battery. The middle contact, No. 11, is connected to the binding post marked G. From the upper contact of the key, a wire leads to contact No. 4 on the T. P. D. T. switch. The current flows through this wire, into the arm No. 1, which is connected to the binding post marked P-1, through the 'phones back to the binding post P-2 to the arm No. 1 and into the wire leading to the binding post L-2, to which the line is connected. The line connected to binding post L-l, which in turn is connected to the negative

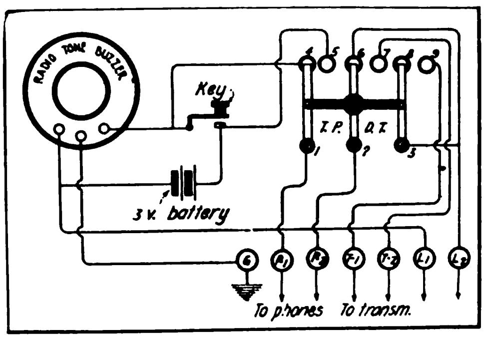


Figure 1—Circuit of field telephone and buzzer

pole of the battery, is in use only when the telephone is employed.

Consider now the telephone connections. Throw the T. P. D. T. switch over on to the other three contacts, Nos. 5, 7, and 9. The transmitter is then connected to the binding posts T-1 and T-2—T-1 being the lower contact on the transmitter and T-2 the upper contact.

Starting at the positive pole of the battery a wire leads to the lower contact of the key also to contact No. 5 on the T. P. D. T. switch. The circuit continues through arm No. 1 into the telephones through P-1, out through P-2 into arm No. 2, through contact No. 7 to binding post T-2 to the upper contact of the transmitter. When you speak into the transmitter, it causes the current to flow through T-1 through No. 9 and arm No. 3 connected to L-2, which is part of

the main line. The negative side of the circuit extends to one binding post of the buzzer, while the other side connects with binding post L-1 which completes the circuit. Therefore the operator may use whichever circuit he desires.

The required articles for this set are listed below:

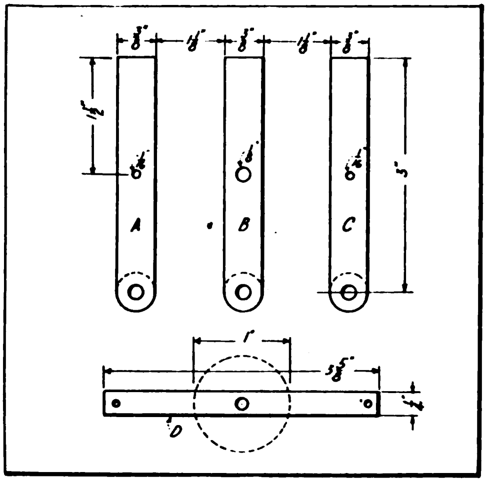


Figure 2—Showing position of cross arm

1 Radiotone buzzer (Electro Imp. Co. Nr. 1K 1800).

1 Strap key (Electro Imp. Co. Nr. C. E. 1118).

Telephones—single one or pair (E. I. Co. Nr. AX1024a).

1 transmitter (E. I. Co. Nr. A. G. E. 6080) or any other make of low voltage (3 volts) transmitter.

7 binding posts, any make or style T. P. D. T. switch.

The construction of this switch is described further on.

The buzzer I have adopted is well suited for this service. The telephones are of the correct resistance for good response. As the receivers and transmitters are to be used in combination, there must be a way to support the transmitter.

Any style of strap key may be used, as they are all built in the same way, but I recommend the E. I. Co.'s as the composition base is waterproof and not as easily broken as a wooden base. This must be taken into consideration

in constructing a portable set, subjected to a great amount of rough handling.

The triple pole, double throw switch consists of the following parts:

3 metal arms A, B and C.

1 cross arm D.

3 flat headed machine screws ⅛ in. diameter.

1 flat headed machine screw ⅛ in. diameter for knob.

1 knob drilled and tapped for a ⅛ in. machine screw.

2 small 1/16 in. diameter copper rivets.

6 switch points.

Washers and nuts.

The three metal arms have the same dimensions, 3 in. in length, ⅜ in. in width and 1/16 in. thick. Arms A and C each have a ⅛ in. hole 3/16 of an inch from the end properly centered; also two 1/16 in. holes 3/16 in. from the sides and 1½ in. from the end. Arm B has a ⅛ in. hole 3/16 in. from the end and a ⅛ in. hole 3/16 in. from both sides and 1½ in. from the end.

The cross arm is 3⅜ in. in length and ¼ in. in width. There are two 1/16 in. holes, 3/16 in. from each end and ⅛ in. from the sides. The center hole is ⅛ in. diameter and is 11/16 in. from the end. This cross arm is placed across the three main arms as shown by dotted lines in figure 2, and riveted (not tight) so that each arm is able to turn in its place. A ⅛ in. 8/32 machine screw is then placed through the center hole and a typewriter knob is screwed on.

In a forthcoming issue, the construction and mounting of the set will be described.

Lieut. R. D. Greenman, *New York City*

A Detector Holder for Accurate Adjustment of the Contact Pressure

SOME two or three years ago I constructed a detector holder as per the accompanying drawing, and it occurred to me that it might interest the readers of "The Wireless Age."

It will be noted finally that my holder not only shows the pressure on the crystal, but also indicates the par-

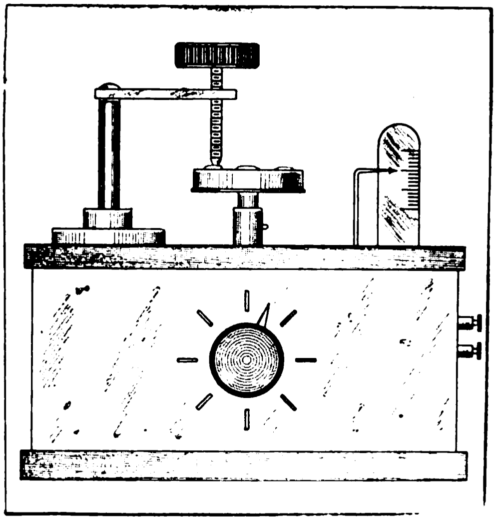


Figure 1—Front view of the detector holder

ticular mineral being used at the time that the test is taken.

I have given no direct measurements for this apparatus first, because the essential parts may differ in construction and material, and second, because different size gear wheels may be used.

The advantages of this detector are as follows: The pressure each mineral requires can be determined accurately, thereby affording a better idea of the correct adjustments of the various types of crystals.

It will be noted that each mineral is so arranged in conjunction with the calibrated pointer and scale, that the

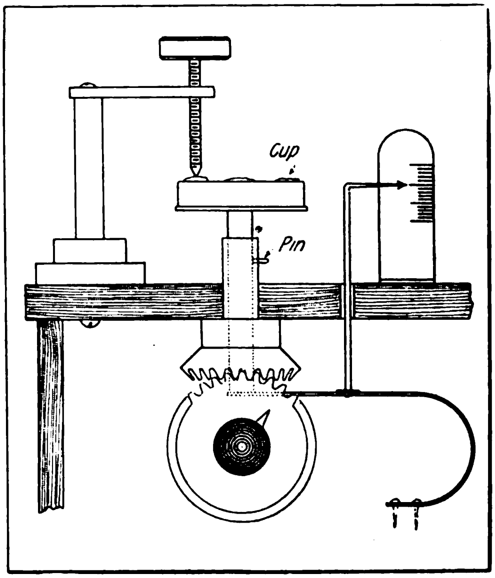


Figure 2—Showing construction plan of the detector holder

particular mineral under test is indicated.

As is clearly shown in the drawings, the detector cup is movable by means of the cog wheel. A graduated scale on the front of the box shows the mineral under test at each change. It will be noted also, that even though the cup is allowed to revolve, this does not in any way interfere with the contact pressure of the mineral under test.

E. T. JONES, *Louisiana.*

A Practical Method of Applying the Marconi-Victor Wireless Records

I have devised a method through which I believe the Marconi-Victor records can be used to advantage in training a large class of men.

As shown in the accompanying drawing, a standard phonograph is used for

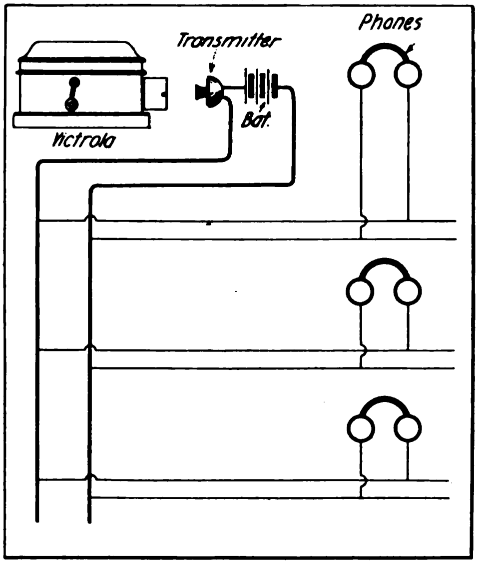


Figure 1—Arrangement to use Marconi-Victor records in class work

the purpose of reproducing the records, but since experience seems to indicate that radio beginners can learn more rapidly by making use of a headphone set, I have shown means whereby the head phones can be used even with the records.

It will be noted that an ordinary transmitter is mounted to pick up the signals produced by the phonograph and at any point along a code practice table these signals can be detected in a headset. This

trains the beginner or student along the lines of everyday practice.

The phonograph-transmitter can be easily muffled so that at a reasonable distance away the signals can only be heard in the head telephones.

While the appearance on the market of these records has been met and welcomed by every student today, with appreciation of the highest kind, it is believed that this suggestion will help to train those desirous of becoming wireless operators for the government in a more radio-like way. The student should be made to use the headset, as it is generally found that the majority of men can copy at a greater rate of speed when making use of the telephone receivers.

E. T. JONES, *Louisiana.*

Linemen's Rubber Gloves Under Test

THE accompanying illustrations show how the Duquesne Light Company of Pittsburgh, Pa., test the insulating qualities of linemen's gloves.

The gloves shown in the photograph are made of pure rubber varying in thickness from 0.038 in. to 0.040 in. (0.97 mm. to 1.02 mm.), having a guaranteed dielectric strength of 10,000 volts and will actually withstand 18,000 volts. The glove is further protected by a horsehide glove, which prevents mechanical abrasion.

To insure the safety of their employees, this company has installed a special laboratory equipment to test gloves immediately upon their arrival from the manufacturer. Those in daily use are tested bi-monthly and must withstand the same test as when new. Linemen, operators and others are compelled to exchange the pair they have in their possession for a new or tested pair on each semi-monthly pay day before their pay vouchers are given them.

The gloves to be tested are transported from the various districts to the laboratory by the general storeroom truck on its delivery days. For this purpose each district has a rugged box in which are two or more trays, one above the other, each divided into a dozen spaces 15 in. long by 2 in. wide

and 5 in. deep (38.1 cm. by 1 cm. by 12.7 cm.). A pair of rubber gloves fits snugly on edge in each space. The hinged cover is provided with a hasp and padlock, while inside on the cover are two spring clips under which the tester at the laboratory slips his report of the tests on a particular quantity of gloves.

Each pair of gloves successfully passing the test is placed in a specially

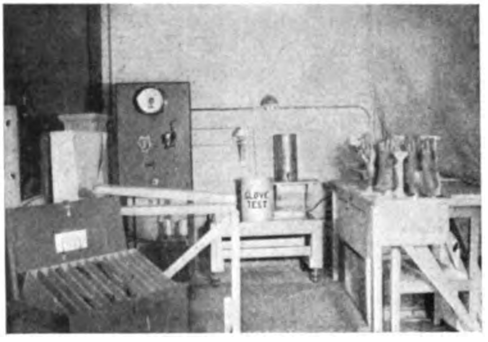


Figure 1—Testing rubber gloves

made envelope 14½ in. long by 4 in. wide (36.8 cm. by 10.2 cm.). When thus enclosed they are placed on edge in the trays, one in a space. The lineman or operator receiving a pair of gloves, sealed in an envelope is assured that they have been properly tested.

The apparatus for making the insulation test is simple, but complete. One pair of gloves is tested at a time being slipped into a specially constructed holder made of copper. This permits the glove to stand with the wrist or gauntlet end open, so that it can be readily filled with water to within 1 in. (25.4 cm.) of the top. For convenience in filling, a spigot is attached to the tank.

The glove holder is immersed to within one inch of its top in an iron bucket of water. Ten thousand volts are applied between the water inside the gloves and that on the outside. The transformer is located on the floor behind the switchboard, its high-tension insulators being visible in the photograph. The volt-meter on the switchboard is connected to the 110 volt or low-tension side of the transformer, but its scale is calibrated to indicate

the corresponding high-tension voltage.

A rheostat is connected directly across the 110 volt line and arranged to give an unbroken range of voltages from zero to full rated potential of the primary windings. When the testing

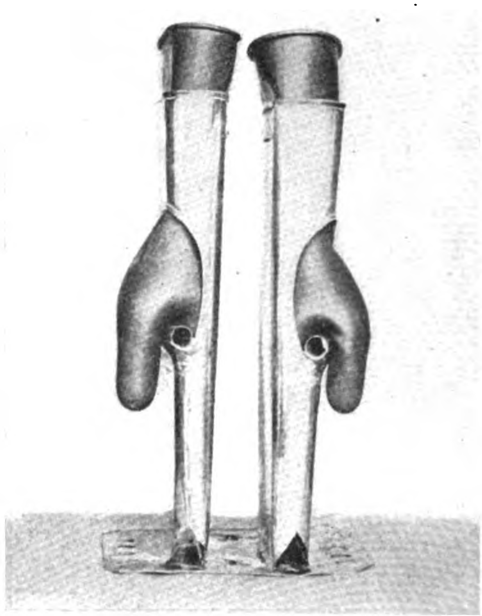


Figure 2—Rubber glove holders for tests

of rubber gloves was first begun on a large scale, investigations were conducted to determine both the charging and the leakage currents of the gloves. It was recognized that the water inside the glove separated from that outside the glove by the rubber wall, constituted a condenser, and that the charging current together with the leakage current could be indicated on a milliammeter in the high-tension circuit. The instruments used for these tests include a very delicate pivot-type milliammeter and watt-meter.

The watt-meter does not indicate the charging component of the current, for the reason that this component is in quadrature with the voltage. From tests made on a dozen pairs of gloves the average total milliamperes per pair was found to be 17.13 and the average total leakage per pair

only 0.25 milliampere. The average energy leakage of a pair was 2.51 watts.

These tests were made at 11,000 volts at the frequency of 60 cycles. At 25 cycles the total current per glove, including charging and leakage, would be 7.14 milliamperes, and at 133 cycles it would be 37.01 milliamperes. The leakage current was the same proportion of the total current as with the 60-cycle tests. The leakage currents have been found so negligible that it was decided that any glove which would stand the 10,000 volt test for one minute is a safe one to use.

Attention is called to the fact that when a glove breaks down under this test a quick acting circuit breaker in the low-tension circuit of the transformer gives the necessary protection to the equipment.

The writer is indebted to Mr. C. W. Ward, Supt. of the Laboratory of the Duquesne Light Co., for the accompanying photographs and data, which should be of special interest to electrical engineers dealing with high tension currents.

FRANK C. PERKINS.

A Wireless Bungalow

ALTHOUGH amateurs cannot use their wireless apparatus at the present time, there is no reason why they cannot make preparations for the future.

One matter which might receive the amateur's attention, is the design of a wireless bungalow for housing his apparatus. The plans of a shack which I constructed are shown in figures 1 to 4 inclusive. This building was erected at a comparatively small cost and afforded a neat wireless room which was away from noises of the house and yet was very comfortable. The best location for the building is directly underneath the lead-in wire from the aerial.

The foundation for the floor is made from six two by fours arranged as in figure 1. The necessary dimensions are shown in the illustration. The foundation is then covered with three-quarter inch matchboards.

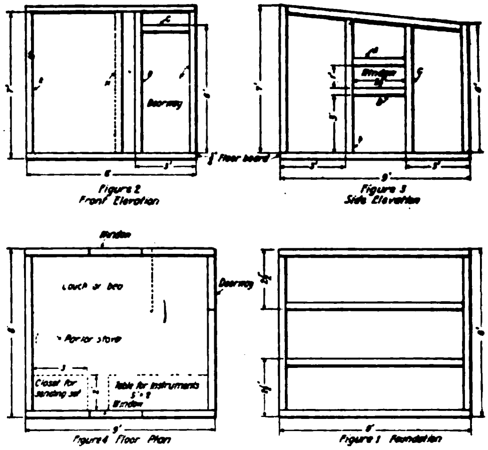


Diagram of building plans for a wireless bungalow

When the floor is completed, the framework should be started.

Figure 2 shows the necessary dimensions for the front frame. The frame for the back is similar except that pieces E and F are six feet high instead of seven. Also in the back frame, piece C should be left out and piece D moved to the position shown by the dotted lines H, figure 2.

The sides are constructed as in figure 3. A space is left on both sides for a window. If the dimensions of the window need to be altered, they can be changed by moving any of the pieces A-B-C-D. I found that two windows of the size shown afforded plenty of light.

The framework for the roof can be made very similar to the floor. As soon as the framework is completed, the building is covered with matchboards and the roof with tar-paper to make it waterproof. If the owner so desires, he can cover the whole outside with tar-paper, and this will keep out much of the wind and cold. After the wireless cabin is finished, it is an easy matter to fix up the inside and lay out the instruments. In one corner I made a closet, or silence cabin, in which I placed my sending set only. Figure 4 shows the exact layout. This left plenty of room for the instrument table, a bed, three chairs, and a stove to drive away the cold on winter evenings.

Wesley Bradshaw, *Connecticut.*

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

A. R. L., Nashville, Tenn., inquires:

Ques.—(1) I am acting as a guardian for a young man who contemplates taking up radio work in the government service. He desires to educate himself along wireless lines by home study.

Ans.—(1) He should make a thorough study of the quenched spark discharger transmitting apparatus, and the wave length changing switches. He should also study the processes of tuning transmitters and receivers by means of the wave meter. Another subject of vital importance is the practical use and operation of vacuum tubes. The fundamental principles of the undamped wave transmitters should receive consideration, particularly the arc system.

* * *

D. R. A., Portsmouth, Va.:

We cannot and will not publish during the life of the war, diagrams of radio apparatus employed by the government. Such equipment as was generally known previous to the war period can be discussed through these columns.

* * *

B. D. R., Boston, Mass.:

The resistance of the spark gap in radio transmitters ranges from a fraction of an ohm up to 8 or 10 ohms. The actual value depends on the materials of the electrodes and upon the capacity in the circuit and the damping.

* * *

R. A. N., Chicago, Ill.:

The following formula can be employed to determine the pull in pounds of a magnet upon its armature. This is a fundamental formula:

$$F = \frac{B^2 A^1}{11,183,000}$$

While F = the pull in pounds.
B = the magnetic density in lines per square centimeter,
A = polar area in square centimeters.

* * *

B. A. L., Fort Leavenworth, Kan., inquires:

Ques.—(1) Will you inform me and my associates why it is necessary to advance or retard the spark on a gasoline engine in order to secure the maximum power?

Ans.—(1) It requires an appreciable fraction of time from the instant the spark discharges across the spark plug until com-

plete ignition of the mixture drawn on at the intake stroke is obtained. Since the most effective results are obtained from an explosion when the piston of the engine just begins the downward stroke, the spark must be set to occur so that the full force of the explosion is obtained when the piston is in this position. At higher engine speeds, the spark is made to occur earlier than at lower speeds in order that combustion may take place at the proper moment on the downward stroke of the piston.

Ques.—(2) What is the function of the distributor in a gas engine ignition system?

Ans.—(2) This device is a mechanically operated high voltage switch which supplies high voltage current to the proper spark plug in the firing sequence.

Ques.—(3) How is the high voltage current for firing the mixture obtained?

Ans.—(3) It may be obtained from an induction coil fitted with a magnetic interrupter, the coil being fed by a storage battery or dry cells, or the current of a low voltage alternating current magneto may be sent through the primary of the induction coil instead of direct current. High voltage currents also may be generated directly in the armature of a high tension magneto. One type is of novel construction. The induction coil is in reality mounted on the revolving armature. As the armature poles pass between the poles of a permanent or horseshoe magnet, a low voltage alternating current is induced in the heavy current coil. This is interrupted by a circuit breaker at the end of the armature. A high voltage current is then induced in the secondary or fine wire winding, which is wound directly over the primary coil. Such magnetos generate potentials from 10,000 to 15,000 volts.

* * *

E. V. A., Fort Worth, Tex.:

A simple repulsion motor for alternating current consists of an armature, field poles and a commutator. The windings of the armature are similar to those of a direct current motor, the coils being connected to commutator segments upon which rests carbon brushes. These brushes are short circuited by an external conductor. The field winding is similar to the usual type of induction motor.

When the current is turned on the field winding, the armature is set in rotation, and when it attains a certain speed, a governor mounted on the armature short circuits the windings, at the same time lifting the brushes off the commutator to prevent wear. The motor then runs as a squirrel cage induction motor.

* * *

E. R. B., Providence, R. I., inquires:

Ques.—(1) My friend and I have had an argument concerning the effect of taking out a leyden jar in a transmitting set where two banks of condensers connected in a series-parallel are employed. In the example under argument, we considered a condenser, which consisted of 12 leyden jars, 6 in parallel in each bank, and the two banks connected in series.

My friend argues that if we remove one condenser from the six on one side, we should take out another condenser from the opposite side in order to effect a balance. I told him that this was unnecessary. I also held that by making this change the capacity of the condenser battery is increased. Can you help us in this matter?

Ans.—(1) The removal of the one jar from one bank of the condenser will place a slight additional strain on the bank having the smallest number. This will reduce the capacity of the complete condenser. The added strain imposed upon the jars by the removal of one jar, need not be given consideration, but if two or three jars were removed from the bank, then, the banks should be equalized. You should keep in mind that when two or more condensers are connected in series the resultant capacity will always be less than the capacity of the smallest condenser in the group.

Ques.—(2) If a wireless set will work as well with a simple parallel connection of condensers as with a series-parallel connection, why is the latter connection employed in view of the fact that a greater number of leyden jars are required?

Ans.—(1) In the earlier wireless systems it was thought desirable to employ high transformer voltages, but it has been demonstrated by later experiments that as effective results are obtained from transformers giving secondary potentials from 8,000 to 15,000 volts. In earlier systems it was necessary to split the condenser into two banks to protect the dielectric. The commercial leyden jar of today will withstand potentials up to 15,000 volts without puncture. Hence when the secondary potential is less than 15,000 volts a parallel connection is invariably employed.

You must also take into consideration that with the high frequencies employed in modern wireless sets such as 500 cycles, if the condenser capacity is to remain the same as in the old time sets, the voltage of the transformer must necessarily be reduced.

Ques.—(3) Does the Marconi magnetic detector rectify incoming oscillations?

Ans.—(3) The exact functioning of this detector is a matter of much argument, but it is certain that it converts a group of incoming oscillations into audio frequency pulses which actuate the telephone diaphragm.

* * *

P. R. A., New London, Ct.:

Details concerning the construction of the thermo-couple type of aerial ammeters in use by the Marconi Company are not open for publication.

* * *

V. D. A., St. Louis, Mo.:

If one electrode of the electrolytic valve consists of a plate of platinum and the other a plate of lead, the results obtained during the flow of current vary with the direction of the flow. If the aluminum plate is the anode, a film of oxide of aluminum is

formed on its surface which stops the current. But when the aluminum becomes a cathode the film disappears. When an alternating E. M. F. is applied to the electrolyte the current can travel freely in one direction, i.e., from the lead through the liquid to the aluminum, but it is opposed in the opposite direction.

Book Reviews

Leadership and Military Training. By Lieut. Col. Lincoln C. Andrews, U. S. A. Cloth binding, 4½ x 6 inches; 191 pages. Lippincott. Price $1.00 net.

Colonel Andrews' text deals almost entirely with the psychology of successful handling of soldiers. The volume is intended to guide inexperienced officers placed in command of men for the first time and to make clear to recruits the problems of the commissioned officer and some of the responsibilities not covered by drill regulations. Pointed observations are included on maintenance of discipline and morale of raw troops and control of men on the battlefield. The material which points the way to best results in the conduct of drills classifies the instruction as disciplinary and instructional and covers both close and extended order, battle exercises and maneuvers. Many phases of practical instruction are commented upon and rules given to coordinate the efforts of the whole command. An officer of limited experience will find this work of special value to him, for the volume contains hitherto unpublished advice on the elements of leadership, rarely analyzed and seldom reduced to printed form.

Obtainable through the Book Dept., The Wireless Age.

Military Instructors Manual. By Capt. James P. Cole and Major Oliver Schoonmaker. Cloth binding. 4½ x 7½ inches; 494 pages. E. N. Appleton. Price $2.00 net.

A real service has been done officers of our new army by the preparation of this book. It is a condensation of the instruction given at Plattsburg by the men who conducted the training, its particular value resting in the fact that the text covers the new warfare, in which the platoon leader for the first time has virtually assumed the role of a company captain. Besides the usual chapters found in works of this nature, covering drill regulations and field work, trench warfare of modern aspect is broadly treated, from formations and construction of trenches, through occupation, defense and attack, the latter subject covering raids, consolidation of mine craters and platoon advances. Genuine assistance to prospective officers is represented in this work, as the material contained between the covers of the book is not easily accessible and would require considerable labor to reduce to the same useful form.

Obtainable through the Book Dept., The Wireless Age.

Hawkins Electrical Guide. Second Edition. By Hawkins and Staff. Cloth binding. 4¾x6¾ inches; 10 volumes; 3,368 pages. Audel. Price $1.00 per volume, net.

At a time when the fate of the United States seems to hang on its sons' knowledge of scientific subjects, the value of these instructive books cannot be overestimated. It is certain that only a small proportion of the

men required for war service in electrical branches can be obtained, and by intensive study students must be prepared to fill the gap. A grasp of electrical fundamentals may be quickly acquired by the Hawkins Guides, for the arrangement of the text is unique. Facts and problems are stated simply and concisely and visualized by numerous illustrations. The statements are then emphasized by questions and answers, fixing the principle firmly in the reader's mind. Special care has evidently been exercised to condense the answers, so memorizing is not laborious. Exhaustive captions, descriptive of apparatus illustrated, are a further aid to impressing construction details on the student mind.

The full set of guides, carefully studied, equip the layman with a practical fund of why and wherefore electrical information, covering consécutively: magnetism, induction, dynamos and armature windings, management of dynamos and motors, instruments, testing, wiring and distribution systems and storage batteries. Alternating currents are then discussed and alternators, A.C. motors, transformers, converters and rectifiers described. Switch boards, circuit breakers, measuring instruments and A. C. wiring are presented in detail and power stations and telephone work explained. Railways, motion pictures and automobile ignition are additional subjects, followed by the telegraph, wireless, bells and lighting. The final volume deals with modern applications of electricity, concluding with the X-ray.

Obtainable through the Book Dept., The Wireless Age.

Manual of Military Aviation. By Major H. L. Muller, U. S. A. Cloth binding. 4¼x7¼ inches; 308 pages. Banta. Price $2.50.

Into this compact volume the author has crowded a very considerable amount of valuable information for those new in aviation service. Basing the manual on American and foreign rules, regulations and practices, perhaps the most complete arrangement of theoretical instruction material has here been assembled for the development of skilled personnel. The author divides his subject into five parts and an introduction. Historical matters are first disposed of and the body of the text then takes up the service of aviation by classifying aircraft and defining the various parts. Training is the succeeding subject, covering personnel and schools, with rules for selection and operation of the latter; duties ment and care of matériel made clear. A chapment and care of material made clear. A chapter is then devoted to aeronautic motors followed by one on instruments. The science of aviation is then discussed, the subjects being meteorology, navigation of the air and flying. The reader is then invited to view military aviation as an art, being instructed in the fundamentals of war service in the air, organization and operation of units and the principles of combat, reconnaissance, coast defense and naval air service, and anti-aircraft defenses.

There is a distinct place for Major Müller's book in the literature of aviation and the method of presentation of his subject is to be highly commended. So well has the task

been accomplished, in fact, that it seems particularly unfortunate that illustrations are so few and index and contents page references omitted, the volume thus losing much of its value as a reference work. For the prospective aviator and the one in training, however, the book will be found of real value.

Obtainable through the Book Dept., The Wireless Age.

The Flyer's Guide. By Capt. N. J. Gill, R. A. Cloth binding. 5¼x8½ inches; 153 pages. Dutton. Price $2.00 net.

This volume is a handbook of elementary character. The author relates from a British viewpoint the steps necessary to become an aviator. He then covers in outline the theory of flight and engine principles. Lack of illustrations and brevity of text take this work entirely out of the textbook class, but as preliminary reading matter for the prospective student it will find favor.

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Aircraft Mechanics Handbook. By Fred H. Colvin. Cloth binding. 5x7½ inches; 402 pages. McGraw-Hill. Price $3.00 net.

In the preparation of this volume the compiler evidently had in mind assembling various items of established practice and setting them down in convenient reference form. In this he succeeded beyond question of a doubt, for the work includes sufficient valuable data on the various parts and auxiliaries of aircraft to find a place of ready usefulness with mechanics and inspectors. No attempt has been made to prepare the volume for the student, the text is of a character valuable, however, to mechanics in kindred lines who are engaging in airplane work for the first time. The subjects have been intelligently illustrated and carefully selected and the book should become popular in the broad field for which it has been designed.

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Offensive Fighting. By Major Donald M. McRae. Cloth binding. 4¼x6 inches; 196 pages. Lippincott. Price $2.00 net.

The junior officer, upon whom falls a large share of the responsibility for successful scouting and raiding in No Man's Land, has in this volume a text specially designed to carry him through his tasks. The author's knowledge of his subject is not theoretical; he has been over there with the Canadians and the problems he solves for our new lieutenants are based on his personal experience. Mine crater consolidation is explained and discussed; trench raids and their various objects and methods of execution are explained and practical instruction is given on the subject of patrols and the control of No Man's Land. The concluding half of the book discusses the fine points of co-operation between infantry and artillery, the infantry in attack, and what trench routine comprises, including the duties of officers and the employment of men. The text is well illustrated and written in a manner which aids quick assimilation of the very valuable suggestions it contains.

Obtainable through the Book Dept., The Wireless Age.

Aircraft in War and Commerce. By W. H. Berry. Cloth binding. 5¼x8 inches; 292 pages. Doran. Price $1.50 net.

The case for the airplane during the war, and after, is interestingly set forth in this book. Germany's leadership in the air at the beginning of war is told in a review of European development prior to 1914. The progress of the Allied nations since is covered and the air future of these nations predicted. The book is rather a series of non-technical essays, of great interest to the general reading public that seeks information on the newest of arts but is not concerned with the mechanics of aviation.

Obtainable through the Book Dept., The Wireless Age.

Winged Warfare. By Major W. A. Bishop. Cloth binding. 5¼x7¾ inches; 272 pages. Doran. Price $1.50 net.

If any special distinction was to be awarded to the author of the best personal narrative on his career as an aviator, first honors would easily go to Major Bishop. His book is not only well written, but carefully plamned to convey a considerable amount of knowledge to the layman without mental burden. This flyer possesses a sense of humor and proportion, in addition to which he has lived through a remarkable series of experiences. The reader who seeks a broad-gauged view of what the military airman does, and is required to do, need go no further than this book; the author in telling his experiences has covered very completely the subject of aerial warfare in bang-up story-telling style.

Obtainable through the Book Dept., The Wireless Age.

Navigation. By George L. Hosmer. Cloth binding. 4¾x6¾ inches; 214 pages. Wiley. Price $1.25 net.

Professor Hosmer's work on navigation is timely and sensible. Many officers will be needed for the new marine fleets of the United States and this volume has been carefully designed to present the study of navigation so aspirants may successfully pass the examinations for navigators. A noteworthy departure from usual practices has been made in this textbook. Algebraic formulae have been omitted and theory replaced by working rules, thus offering a splendid chance for the man whose education includes only simply arithmetic. Another valuable feature is the series of unsolved navigation problems to be worked out by the reader; these follow careful explanations and practical application of methods of computation which point the way for the novice.

In all respects the book is well planned and may be unreservedly recommended to those who are anxious to master the art of navigation.

Obtainable through the Book Dept., The Wireless Age.

On Navigation Simplified. By C. E. MacArthur. Cloth binding. 4½x6 inches; 121 pages. Rudder Pub. Co. Price $1.00 net.

Prospective masters and mates of sea-going vessels are catered to in this little handbook of practical navigation. Clear understanding of the various problems is arrived at through full explanations and illustrations of all the rules used in the solution.

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AUTHORS